SCIENCE IN SECONDARY SCHOOLS IN BRITAIN

UNDER the Government's five-year plan for 'Secondary Education for All', a phrase which seemed to be popular in official circles fifteen years ago, nearly £300 million will be spent on new and improved secondary schools. About 1,000 new science laboratories are being erected and equipped each year, and although most of these will be in new schools, special attention is being given to the needs of existing grammar schools. There has been a steady increase in the number of graduate teachers of science and mathematics in the past few years. But this number is still not satisfactory, and the general level of the qualifications of science and mathematics teachers is even worse. Although it is admitted that there is a position in the grammar school for the lower second-class, the third-class or the pass-graduate, successful science teaching demands a scientific ability and background, cultural in the fullest sense of the term, the incidence of which is not great. A pleasing feature of the present situation is the probability of better standards in some of the training colleges because of the extension of the course to three years.

A recent Ministry of Education pamphlet*, which modestly describes itself as such although it runs to 164 pages, is timely and stimulating although it does not say much that is new. It is written enthusiastically by a group of Her Majesty's Inspectors whose aim is to help to stimulate the better teaching of science. The authors do not make the mistake of trying to provide syllabuses for each type of secondary school, and, although a few matters are selected for detailed consideration and illustration, the treatment of the topics is general. The booklet commences, as does "The Teaching of Science in Secondary Schools" compiled by the Incorporated Association of Assistant Masters and the Science Masters' Association, published some months earlier, with a short history of science teaching in England and a short but very useful account of the English tradition of science teaching. These matters are worthy of serious study, because only by a reasonable assessment of past failures and successes can we hope to build satisfactorily in the future.

Of particular interest is a revealing chapter, which could only have been written adequately by H.M. Inspectors, on conditions under which science is taught in Britain. Then follows a chapter of three pages on the development of children and the teaching of science. This seems to be the core of the whole matter and it will be noticed later. There are useful chapters on the design of science courses and some hints on the approach to general science.

The book makes a plea for a more honest, stimulating and pedagogical approach to what is so often wrongly called experimental work in schools. There are objections to heuristic methods in their crudest forms, but the ideas of H. E. Armstrong, a remarkably fine teacher of chemistry, should be considered in relation to modern requirements and possibilities.

The investigation of some simple problems in dynamics and apparent solar diameter, chosen, no doubt, to escape for a while from the beaten track of elementary science teaching, have been given a detailed treatment and illustrated with excellent photographs and diagrams.

The teaching of biology, chemistry and physics are succinctly reviewed in order. Part 4 of the book deals briefly with practical considerations of immediate importance: the design of laboratories, laboratory assistance, apparatus-making and suitable tools for this task. Once again, the qualities of a good science teacher are set out. The interesting thing about this is that it has been said so often before and in the same terms, but with little effect. Perhaps it is pessimistic to suggest that few science teachers recruited since the end of the War will meet the desiderata so ably set forth.

It may be hypercritical to note such a sentence as: "It is simple to tow a trolley fitted with a speedometer by means of a spring balance" and to call a difference of 5 per cent in the results of simple astronomical observations a close agreement. With so many topics briefly considered in so short a space, it has been difficult to avoid occasional superficiality. Chapter 10, a short essay on scientific method and the place of mathematics in it, is brilliant. There is a great deal of useful matter in this little book, and much of its worth only reveals itself by a second careful reading. It is the product of the mature thought of many able minds and is warmly recommended not only to actual and potential teachers of science and educationists in general but also to all those who have any interest in science. With all this, however, there is still one important matter—in fact, the most important—on which a little has been said in Chapter 4 and, indeed, little is known. Under the Education Act of 1944, secondary education was divided into grammar, technical and modern. The grammar schools continued on the way which had been laid down for them by the syllabuses of the external examinations, with perhaps a slight tendency to more enlightenment in methods and content in science teaching, but with still too great a stress on the 'facts' of elementary science and the repetition of simple, well-tried demonstrations, usually with much dictation of notes. Some schools did and do make an earnest endeavour to get the best out of science teaching by considering the nature of the study, the planning and carrying out of experiments, the methods of dealing with observations, the problems of error and confidence, the applications of science, the

* Ministry of Education. Pamphlet No. 38: Science in Secondary Schools. Pp. vi+164+6 plates. (London: H.M. Stationery Office, 1960.) 6s. net.

scientific spirit and so on; but too often science teaching was measured by its efficiency in producing passes at Ordinary Level, and in the sixth form at Advanced Level, in the General Certificate of Education examination; and in many schools, particularly girls' schools, it was not efficient even there.

The secondary technical school in Britain has suffered through lack of equipment and teachers, but in the former there is much improvement. Selection for secondary technical schools is largely unsatisfactory, since the more intelligent children among those who fail to secure places in grammar schools are sent to technical schools. A consideration of the selection problems for children suitable for technical education is long overdue. Finally, there are the secondary modern schools. It is not unfair to say that, even with a certain tradition inherited from the central schools, they have largely failed to find a philosophy or even a scheme of work for themselves. No doubt the problems of staffing such schools with men and women with adequate science and teaching qualifications have been insuperable. Nevertheless, in view of some of the recommendations of the recent Crowther Report, the future of the secondary modern schools is of paramount importance. There can be little doubt that their comparative failure to establish themselves educationally and socially has led to cries, with political overtones, for comprehensive, bilateral and other schools.

The science-teaching triangle is child, teacher, equipment. The best equipment in the world—and much of it in British schools is surprisingly good—does not make a good teacher; and even a good teacher will not improve the intelligence of a child, even if good teaching may awaken interests and may apply whatever natural intelligence is found in the pupil to the best advantage.

Much research is necessary concerning the child-mind in relation to science, and should be undertaken by institutes of education and postgraduate teachers. Various natural bents, intelligences and levels of maturation will have to be considered in relation to the scope and content of science syllabuses, the origins of interest, and the methods and techniques of teaching—and all this in relation to the various aims which educationists have in mind, in teaching science at all.

THE DILEMMA OF THE FAR EAST

Population and Progress in the Far East

By Warren S. Thompson. Pp. ix+443. (Chicago: University of Chicago Press; London: Cambridge University Press, 1959.) 56*s*. 6*d*. net.

THIS is an important book about an important subject—the struggle of half of the world's people to keep production ahead of population growth. Its merit lies essentially in the wealth of information and analysis it supplies about the basic resources, technologies, economic policies and social customs which governments of Asian countries are desperately attempting to manipulate to break through the Malthusian barriers of subsistence. Chapter by chapter, Prof. Thompson lays out the patterns in Japan, India, China, Pakistan, South-east Asia and Taiwan and Korea.

The reader naturally hopes that out of the great knowledge which Prof. Thompson displays there will emerge a pattern of hope; but his conclusions are sober, if not gloomy. He warns that even Japan, now generally listed as Asia's most prosperous country and the one clear case of population control, is yet in a precarious position, with a cultivated area still less than in 1940 and a trading area reduced to "about what it was in 1872". Compared with the rest of Asia, Japan is well advanced along the roads of both economic growth and demographic transition. Not so India, where the author concludes that of the vast uncultivated areas of 124 million acres, probably only 25 million are cultivable, or only enough to take care of present rates of population growth for some 4 or 5 years. However, Prof. Thompson does admit some prospect of increased productivity and of raising investment to some 10 per cent of national product, or sufficient to cope with a population increase of about 1·7 per cent and to bring some slight rise in living standards. But short-run gains will become losses unless the rate of population growth can be slowed down.

As for China, Prof. Thompson also doubts some of the more optimistic claims about unused resources; and emphasizes that if the 1953 census and subsequent official pronouncements about the annual rate of population growth of some 2 per cent are correct, the Chinese problem may prove even more intractable than that of India, although China has almost certainly a much greater area of cultivable but unused land than India.

On the general issue of how to achieve a successful take-off in the process of economic growth, Prof. Thompson shows himself to be an ardent agricultural democrat and traditionalist. His warnings against undue expectations from innovations, over-capitalization in enterprises that could best be carried out by more intensive use of labour, and insufficient attention to the strength of traditionalism leading to false optimism about the speed with which controls over the rate of population growth can be introduced, are all timely. Nevertheless one feels that he may be a little too conservative here, considering the rate of change that has occurred, and is so clearly still occurring, throughout the whole Asian and African world.

The biggest issue is whether the processes of economic growth and population control can be accomplished within a democratic framework. Prof. Thompson looks with hope to the Indian pattern, although even here he fears there may be too much emphasis now upon industrialization and not enough upon production of food and fibres, which he considers "will almost certainly be the chief source of capital" in all Asian countries. I share his hope that these great issues will be resolved within democratic frameworks; yet there is no proof that they will be, and we have to face the issue that, however much we dislike their political system, the Chinese do seem to be making as much progress as the Indians in trying to resolve the Malthusian dilemma of keeping the tortoise of production ahead of the hare of population growth.

Prof. Thompson's informative and thoughtful book is warmly recommended to those who want to think on the world's other great explosion—population growth.

W. D. Borrie

MAN AMONG THE PRIMATES

The Antecedents of Man

An Introduction to the Evolution of the Primates. By Prof. Sir Wilfrid E. Le Gros Clark. (Edinburgh University Publications: Science and Mathematics Texts, No. 2.) Pp. vii+374. (Edinburgh: At the University Press, 1959. Distributed by Thomas Nelson and Sons, Ltd., 1959.) 21*s*. net.

LE GROS CLARK'S "Early Forerunners of Man" (1934) is one of the basic studies in primatology; but it has long been unavailable, the stock having been destroyed by enemy action during the War. It is also now seriously out of date because of the great increase in knowledge of fossil primates during the past quarter-century. The Munro Lectures at the University of Edinburgh in 1953 gave Le Gros Clark occasion to review the whole subject, and he has now published what is essentially a revision of the earlier book, incorporating the substance of these lectures and also discoveries made since 1953.

"The Antecedents of Man" covers the same field and has nearly the same organization as "Early Forerunners of Man". The bulk of the book, as before, comprises a series of chapters on the comparative anatomy of the dentition, skull, limbs, brain, special senses, digestive system, and reproductive system of the primates. All are treated from a taxonomic and phylogenetic point of view. Fossil evidence on the hard parts and endocranium is included. These chapters do not differ greatly from the earlier version but have been well brought up to date. A wholly new introductory chapter on modes and processes of evolution and the interpretation of pertinent evidence is a useful and welcome addition. An older chapter on the reference of the tree-shrews to the primates, a radical idea in 1934 but now widely accepted, has been eliminated, and the evidence has been given where appropriate in other chapters.

The revised final chapter on evolutionary radiations of the primates particularly reflects new palæontological discoveries. Among the earlier forms there is less insistence on a sharp tarsioid-lemuroid dichotomy and on derivation of anthropoids from definite tarsioids. Among the later forms, discovery of the australopithecines and recognition of their near-ancestral relationship to man has made the greatest difference. Le Gros Clark was among the first to recognize that relationship, and he has maintained it in the face of polemic criticism. He may be excused a measure of satisfaction, here only faintly expressed, that time and further discoveries have proved him right in the opinion of the great majority of his colleagues. Another extremely important body of discovery since 1934 is abundant Miocene primate material found by Leakey in central Africa and described in large part by Le Gros Clark himself.

The taxonomy of early (Palæocene to Oligocene) primates and their relationships to various primitive insectivore-like groups is now again in a fluid state. From that point of view, this is an unfortunate time to review the group, and this part of the discussion is already becoming out of date. However, one can scarcely wait for study to stop before summarizing past results.

The book is not written down to a popular audience, but it assumes only minimal knowledge of anatomy and zoology. It might, indeed, be considered somewhat elementary for use as a text-book as suggested by author and publisher. For that and also other purposes the absence of a formal reference classification is unfortunate.

There are numerous books, even good books, on fossil man and human origins. This is the only book that places man in true perspective within the whole order Primates and its seventy million years of history. It is an excellent synthesis and summary, and it is warmly recommended. G. G. SIMPSON

ASPECTS OF AERONAUTICAL SCIENCES

Advances in Aeronautical Sciences

Proceedings of the First International Congress on the Aeronautical Sciences, Madrid, 8–13 September, 1958. Edited by Th. von Kármán, A. M. Ballantyne, R. R. Dexter, H. Blenk, H. L. Dryden and M. Roy. Vol. 1: Pp. viii+1–562. Vol. 2: Pp. viii+563–1144. (International Series on Aeronautical Sciences and Space Flight. Division 9: Symposia.) (London and New York: Pergamon Press, 1959.) 200*s*. net the set of two volumes.

THE papers recorded in these two volumes were presented at the first international congress organized by the newly formed International Council on the Aeronautical Sciences, and it is hoped that similar meetings will be sponsored in different countries every two years or thereabouts.

It would be an impossible task for any one reviewer to comment with authority on more than a few of the papers presented, since they cover an immensely wide range of aeronautical science. Forty-six in number (eight in French, four in German, one in Spanish, the remainder in English) they embrace, *inter alia*, mathematics and materials, medicine and mechanics, mixed flows and magnetohydrodynamics. There are general surveys of fields of knowledge, and original contributions; the speed-range covered runs from the zero forward velocity of a vertical take-off aircraft to the escape velocity of a satellite. I can therefore do no more than skip through the volumes, noting here and there a paper of particular interest, and finally giving an overall impression.

In the formation of the International Council on the Aeronautical Sciences and the promotion of the congress, financial assistance was received from the Guggenheim Fund for Aeronautics; it is therefore appropriate that the Proceedings open with the first Daniel and Florence Guggenheim Memorial Lecture. It was delivered by Th. von Kármán, and entitled "Some Significant Developments in Aerodynamics since 1946". It gives a very readable survey of the subject, ranging through supersonic and hypersonic speeds to Newtonian flow, and then over boundary-layer theory and turbulence. One plea should be quoted: "I believe that a systematic nomenclature and classification of these new branches of combined fluid mechanics, electromagnetic theory, and thermodynamics is yet lacking". One may say 'amen' to that.

There follows a group of papers dealing with various problems of high-speed flight—design, navigation, propulsion, the theory of hypersonic flow; an informative little essay from the pen of Lighthill on the dynamics of a dissociating gas is followed by a substantial paper on American experimental work on hypersonics. Next, three papers concerned with thermal effects on structures and one on oscillatory transonic derivatives appear (the authors being

respectively Dutch, Italian, French, and Swedish). The first volume is completed by a dozen papers in groups, dealing with heat transfer, noise (both physical and bio-acoustic), and automatic control.

The second volume opens with a series of substantial papers on boundary layers (particularly boundary-layer control). Next, two general papers survey respectively the subjects of aero-elasticity and of hypersonic flow; they are followed by two papers on ring aerofoils. An interesting Russian contribution from Dorodnicyn deals with the analytical difficulty of calculation in the transonic region, when the governing equations are changing from elliptic to hyperbolic type. Vertical take-off provides the subject for the next group; materials for heat resistance are then discussed in three papers. Two papers on telemetry, three on aviation medicine matters, and three on propulsion methods for astronautics (including ionic propulsion) conclude the volumes.

The general impression gained from browsing through these volumes is entirely favourable. To weld such a variety of papers from so many different sources into a coherent whole must have presented the editors with a major task; they are to be congratulated on the result. The volumes are admirably printed, and only one or two misprints were noticed. As regards the papers themselves, I do not feel competent to judge more than a few, which I found of high standard; in the many other fields I found much of interest and many papers which invite a second more careful reading. A. R. Collar

PROGRESS IN METAL PHYSICS

Progress in Metal Physics
Vol. 7 (1958). Pp. viii+408. 110*s*. net.
Vol. 8 (1959). Pp. viii+330. 90*s*. net. Edited by Dr. Bruce Chalmers and Dr. R. King. (London and New York: Pergamon Press.)

To say that these two volumes maintain the standard, and the interest, of their predecessors in this series is in itself high praise which is fully deserved. To the authors of the articles—and to the editors it should not be forgotten—are due the thanks of all concerned with the ultimate structures of metals, their transformation by heat or mechanical deformation and their alloys.

Volume 7 contains an account of work on the equilibrium, diffusion and imperfections in semi-conductors, justified, as if this were necessary, by the fact that single crystals of silicon and germanium are now available of a purity and perfection which surpass those of metal crystals "by many orders of magnitude". The paper on the physical metallurgy of titanium alloys is a discussion in terms of the fundamental factors involved, of the question "What additions form useful alloys with titanium?". It is obvious that the last words in the perennial problems of the thermodynamics and kinetics of martensitic transformations have not yet been said, as is abundantly evidenced by the noteworthy progress made in the past decade, which is excellently summarized here. That that part of the mechanical energy expended in deforming a metal and stored up in the deformed structure is the essential feature of the cold-worked state has, in general terms, been recognized for many years. That it is the cause of the instability of this structure is equally well known. The account, therefore, of the extent to which this qualitative treatment may be developed into a quantitative treatment is to be welcomed. The final article, a second one on the properties of metals at low temperatures, deals particularly with thermal conductivity, on which a large amount of work has been done, and on certain mechanical properties.

Volume 8 commences with still a third review in this series of the work-hardening of metals. Despite this, the account of new work extends to some hundred pages with getting on for two hundred references. Allied to this is an article on X-ray studies of deformed metals. The fact that metallic crystals are never perfect has long been known, and an account of the defects in pure metals discusses the subject from the point of view of modern knowledge. "Ten years of fairly intensive work has yielded a moderately complete experimental picture of copper and gold, and the theoretical estimates are apparently reasonably accurate", but "it would be unreasonable to expect to find any easy way of extending our knowledge to other metals".

Two articles remain to be mentioned, one a very welcome discussion on grain boundaries. After a period some thirty to forty years ago when these boundaries were the focus of metallographic thought, this, under the influence of the then new X-ray techniques, moved over to the structure of the crystals themselves. In view of the profound importance of the grain boundary on the properties, it is a healthy sign that their nature, still very far from being fully understood, should once again be a subject of investigation. Finally there is an account of the substructures in crystals grown from the melt, a matter of most obvious significance. The cellular structure on the solid-liquid interface of such a crystal of tin, Fig. 15, is so full of interest that one is led to wonder whether the old Quincke hypothesis might not repay renewed examination at the hands of a modern physical metallurgist.

An almost incredible amount of work is summarized in these volumes, and the need of men well-versed in such matters who can, and are willing to, apply this knowledge to modern industrial needs requires no emphasis. F. C. Thompson

FLAME AND EXPLOSION OF GASES AND VAPOURS

Explosions, Detonations, Flammability and Ignition
Part 1: Selected Analytical Studies on Explosions, Detonations, Flammability Limits, and Ignition of Gases, and on Heterogeneous Burning. By Prof. S. S. Penner. Part 2: Experimental and Theoretical Studies of Flammability, Ignitibility and Explosion Prevention. By B. P. Mullins. (AGARDograph No. 31.) Pp. xi+287. (London and New York: Pergamon Press, 1959. Published for and on behalf of Advisory Group for Aeronautical Research and Development, North Atlantic Treaty Organization.) 70*s*. net.

This work is largely an account of recent advances in fundamental knowledge of initiation and propagation of flame in engines powered by gaseous and liquid fuels. Other subjects, such as the extinction of flame and the explosion of clouds of certain metallic powders and coal dust, have comparatively brief notices. Solid explosives are not included.

The work has two principal foci, one being the major interests of a professor of jet propulsion and

the other of an officer of the National Gas Turbine Establishment. The two parts are written almost independently, and might well have been published separately. Indeed, the introduction to Part 2 claims that "it is often evident that a semi-empirical thermal approach can yield results which are much more accurate than a basic theoretical treatment which can usually only indicate orders of magnitude". A closer correlation of theory and experiment may be possible some day, but the authors, in their joint general introduction, say that "much more work must be done before we arrive at anything resembling a complete theory of, for example, flammability limits and ignitibility, particularly in heterogeneous systems", and hope that their monograph "will stimulate fresh ideas and indicate areas of combustion research in which future effort might be directed fruitfully".

Both parts of the book are based on a detailed knowledge of recent advances (up to about 1958) in the study of flame and explosion in gases, vapours and mists. The authors quote from their own contributions, some of which have not previously been published, and from available papers from many sources, including some important Russian work. The bibliographies seem to be thorough and carefully prepared, and the few errors that I have noticed (for example, the mis-spelling of the names of Blecher, Barth and Couriot) will not seriously inconvenience anyone.

The reference (p. 113) to "Semenov's original postulate that an ignition temperature is that temperature at which the initial loss of heat due to thermal conduction etc. is equal to the heat liberated at the same time by the chemical transformation" must have been written in ignorance of Van't Hoff's postulate ("Etudes de Dynamique Chimique", 1884), which reads "Le température d'inflammation est celle à laquelle la perte initiale de chaleur, dûe à la conductibilité etc., est égale à la chaleur que produit en même temps la transformation".

Although the chief value of the book is its review of the researches of the past ten years or so on gaseous combustion in relation to engines, it will be of much value to a wider circle concerned with the use or suppression of flame. The book is not for beginners, who have (as the authors repeatedly indicate) the works of Bone and Townend, Jost, and Lewis and von Elbe in which to find summaries of the older researches on this very intricate subject.

H. F. Coward

ARTIFICIAL INSEMINATION IN CATTLE

Lehrbuch der Rinderbesamung

Grundlagen, Technik, Organisation und züchterische Probleme der Samenübertragung beim Rind. Von Dr. Karl Eibl. Pp. xv+485. (Berlin und Hamburg: Verlag Paul Parey, 1959.) 74 D.M.

THIS book is a thorough and detailed compilation of facts from the literature about artificial insemination in cattle. While a list of the main books on the subject is given, no references to original papers are listed although names and dates are given in the text. It is arranged in six sections the scope of which are indicated by some of the examples quoted below. Section 1 deals with the anatomy and histology of the male organs. The structure of spermatozoa, the pathology of spermatogenesis and abnormal forms are well illustrated. Different forms of artificial vaginas and electro-ejaculation are described. Methods of semen examination such as the impedance test, staining for live and dead sperm and for fructolysis are outlined. In Section 2 the female organs are described. A good illustrated account is given of the development and timing of the fertilized egg from ovary to uterus. Conception rates are also dealt with. Section 3 outlines the history, development and present state of artificial insemination in different countries. Various methods for proving bulls for milk and type are also described. The practical problems of the organization of artificial insemination stations are given in Section 4: plans are given for the layout of centres. Methods of feeding and examining bulls for disease and impotency are included. The significance of testes volume is also discussed. Among the various things described in Section 5 are the different dilutors and the blood grouping of sires and their offspring. Details and illustrations of the apparatus used in the deep-freezing of semen are given and semen banks are discussed. Reference is also made to the carbon dioxide method of storage at room temperatures. In Section 6, and also elsewhere, the problems concerned with semen infected with *Vibrio* or *Trichomonas* are discussed.

This is a very useful book to consult on all questions of artificial insemination in cattle. J. Hammond

ADVANCES IN VETERINARY SURGERY

The Veterinary Annual, 1959

Edited by W. A. Pool. Pp. xxiv+363+36 plates. (Bristol: John Wright and Sons, Ltd., 1959.) 42s.

NO veterinary periodical has as yet, as a matter of editorial policy, sought to provide a comprehensive selected abstract service. "The Veterinary Annual" aims to satisfy this need, and the first edition has made a very good start.

It must be judged mainly on the adequacy and topicality of its reviews of the current literature, which provide the main bulk of the text. The literature of 1958 and part of 1959 is covered in most of the sections as topically as any annual published in early 1960 can be. The reviews cover the diseases related to bacteria and fungi, to protozoa, viruses and parasites, nutritional and metabolic disorders, reproduction and reproductive disorders, neoplasms, radiation and radiology, pharmacology, toxicology, physiology, surgery, technique and apparatus and public health.

The editor, W. A. Pool, has contributed several sections himself, and these are a good indication of the high standard he is setting. He has also avoided, and restrained his contributors (one or two apparently with some difficulty) from, covering up a deficiency of research results by theoretical exercises which may only mislead the veterinary practitioner who is not so well informed on these matters. Indeed the mere fact that these deficiencies due to lack of progress in research are obvious is to the credit of the editor and his contributors.

One major deficiency is the lack of reports of clinical trials of new drugs. This is emphasized by the list of fifty new drugs and appliances together with manufacturers' descriptions—many of which may never be competently evaluated.

Besides the very adequate review of the current literature there are a number of special articles describing veterinary work in the United States of America, Denmark, Sweden, Canada, Australia, New Zealand, Central and South Africa. That by Smithcors about the United States of America is an excellent introductory article which sets a very high standard for those to follow. Various aspects of veterinary practice in Great Britain are also covered under the headings of country practice, horse practice and small-animal practice. Here the contributors are too vague and in none does the standard approach that of Smithcors or of the introduction to greyhound racing by Bateman. In the next edition the editor might pay attention to some of the subjects discussed in his own preface. Contributions relating new methods of husbandry and feeding to the wide range of standards of management existing in Great Britain would certainly become a most fruitful new venture. It should be noted that the small list of new publications included in the book cannot be considered by any means exhaustive.

This annual is strongly recommended to all those many veterinary surgeons and field research workers who lack adequate library facilities or a comprehensive abstract service. G. N. Gould

STEROID CHEMISTRY

Steroids

By Prof. Louis F. Fieser and Mary Fieser. Pp. xvii+945. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1959.) 144*s.* net.

THIS book represents the fourth edition of one first published in 1936 under the title "Natural Products Related to Phenanthrene", the third edition of which was published in 1949. The present book deals entirely with the chemistry of the steroids, which have become by far the most important group of naturally occurring phenanthrene derivatives.

The reviewer's task is a pleasant one because this is a superb presentation, both for the specialist and for the general reader. Biological and commercial interest in the steroids over the past ten years has stimulated a vast amount of chemical research. This might have proved dull, but in fact it has been intimately connected with new applications of physical techniques (for example, infra-red spectra and rotatory dispersion), new theoretical ideas such as conformational analysis, and the development of new reagents. It might fairly be claimed that the steroids have set the pace for the development of alicyclic chemistry over the past decade.

This book can be read with pleasure and profit by workers in any field of organic chemistry, including the specialist on reaction mechanisms, the synthetic organic chemist, the worker who is concerned with the application of new instrumental methods, etc. Not only does this book review most admirably the literature of the subject; but also the authors in many places add their own interpretations and generalizations—and furthermore they pose new problems for research.

All aspects of steroid chemistry are covered, and although the book does not pretend to be a complete catalogue of all the facts, the wealth of detail is such that it may be feared that many research students will be tempted not to bother to look at the original literature.

The general chapters of the book cover the following topics: Chapters 1–2, introduction and structure of the steroid skeleton; 5, physical methods of characterization; 6, oxidation; 7, enes and ols; 8, ketones; 9, displacements and rearrangements; 10, stereochemical correlations and conventions.

The specialized chapters deal with all the main groups of steroids as follows: Chapter 4, vitamin D; 11, sterols; 12, methylsterols (including the tetracyclic triterpenoids); 13, biosynthesis of cholesterol; 14, bile acids and alcohols; 15, œstrogens; 16, androgens; 17, progestogens; 18, homo- and nor- steroids; 19, adrenocortical hormones; 20, cardiac-active principles; 21, sapogenins; 22, alkaloids.

The book is lavishly illustrated with structural formulæ, many of them three-dimensional. A pleasant feature is the inclusion of many personal notes about workers in the field; such insertions would be annoying if they took the place of good factual and theoretical information, but when they are added to a fine scientific presentation, they contribute greatly to the interest of the book.

One of the most important facts about this book is that it is so up to date. The date of publication in the United States was July 1959; there are many 1959 references, and others to work then unpublished. Many monographs to-day suffer so much from serious delays in editing, printing, revision, etc., that this book must provide authors and publishers with a model of what can be achieved; typographical accuracy and the clarity of the formulæ leave nothing to be desired.

The more one reads of the book the more one is amazed at the way in which the two authors have combined a broad view of the subject with a wonderful grasp of detail. It is significant that in a book of 900 pages they have not followed the common trend of making it a collaborative effort. They have, however, obtained the help of colleagues in the field in another way; the entire manuscript was read by six steroid chemists outside the authors' laboratory; individual chapters and sections were sent for comment to nearly every senior worker in each special branch of the field, and the authors generously acknowledge the very valuable help of these colleagues.

If I may offer one or two suggestions regarding further improvement of the book in its fifth edition, they are the following: the subject index, although very full, might be extended by the inclusion of an index of formulæ of the pattern used in *Chemical Abstracts*, and also an index of reactions; this might be of the type used in Theilheimer's "Synthetic Methods", or perhaps it would be more popular if it did not need a special technique for decoding. The authors have indexed some classes of reaction, including oxidation, reduction, hydrogenation, but not, for example, hydrolysis. Another useful addition to the index would be the names of 'classes' of compounds, such as glucuronides and sulphates.

All steroid chemists will be still further indebted to Prof. and Mrs. Fieser for this wonderful achievement, and it is hoped that many other chemists will take advantage of the mass of information and ideas which is laid before them in this book.

The minor criticisms of the index are rather like the comments of the traveller who directed attention to the ticking of the clock in a Rolls-Royce—for this is indeed a Rolls-Royce among monographs of organic chemistry. W. Klyne

Applied Hydrodynamics

By H. R. Vallentine. Pp. viii+272. (London: Butterworths Scientific Publications, 1959.) 50*s*.

THIS is a text-book not so much of applied hydrodynamics as of classical theoretical hydrodynamics in an accessible form for application. It is meant for students of engineering and physics as well as applied mathematics.

The mathematics of the subject is expounded in some detail. A student with limited mathematical ability will probably find enlightenment here on subjects about which he would learn little from a more concise account, though occasionally he may have difficulty in seeing the wood as well as the trees.

In an introductory chapter, readers are forewarned of the important differences between inviscid and real fluid-flows. This is welcome. The matter might reasonably have been given more emphasis throughout the book, and in a future edition the apparent identification of near-irrotational flow outside boundary layers with turbulent flow ought to be corrected.

There is a chapter on the numerical and experimental-analogy methods for solving Laplace's equation. Here and elsewhere seepage problems are included among the illustrations; these help to justify treating solutions for boundaries at which separation would occur in ordinary fluid-flow at high Reynolds numbers. Aerofoil and wing theory get less attention than they deserve, apart from aerofoils obtained by conformal transformation of circles.

The book will probably be most useful as a hydrodynamics supplement to one of the better of the available engineering text-books of applied fluid mechanics, to be dipped into as required. Its readers should be well prepared with an understanding of real fluid flow, for while the reminders in it of the realities of applied hydrodynamics are useful, they are not complete enough to stand alone. E. P. SUTTON

British Caenozoic Fossils

(Tertiary and Quaternary). Pp. vi+130 (44 plates). (London: British Museum (Natural History), 1959.) 6*s*.

THERE has long been a need for some kind of comprehensive yet concise handbook illustrating the fossils most commonly found in the various strata of Great Britain. "British Caenozoic Fossils", prepared by the staff of the Natural History section of the British Museum, is the first of a series which will eventually embrace also the Mesozoic and Palæozoic fossils of Britain, and will be widely welcomed. The present volume contains line drawings of 354 Tertiary and Quaternary fossils, together with tables giving their geological distributions and a coloured map showing the principal fossiliferous localities.

The aim of the series is modestly described in the preface as being "to enable the young, or those without experience, to know what fossils they may expect to find, or, even more important from our point of view, to identify for themselves those they have collected"; but there can be few mature professional geologists in Britain who would not be glad to have this book on their shelves or, more to the point, in their pockets when in the field. For the latter purpose the book is ideal; it is compact (approximately 8½ in. × 5½ in.), and clearly printed on strong paper which is unlikely to be ruined by the occasional spot of rain. The drawings are a delight to the eye, and the typography and layout show a concern for clarity and style in every detail which is all too rare at the present day, and surely unequalled in a book of this price. The only criticism which might be levelled at it is that a work of such excellence deserves a more robust and attractive cover. The companion volumes will be eagerly awaited.

Organic Syntheses

Vol. 39. Edited by Max Tishler. (An Annual Publication of Satisfactory Methods for the Preparation of Organic Chemicals.) Pp. vii+114. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1959.) 32*s*. net.

OVER a long period a large number of the more familiar organic chemicals have been dealt with in this annual publication of satisfactory methods for their preparation. The later volumes have accordingly contained a larger proportion of more specialized structures, many of which were unknown at the inception of the series. The great diversity of organic types represented is well illustrated in the present selection of 31 synthetic preparations, including such items as benzeneboronic anhydride, di-*n*-butyldivinyltin, 9-methylfluorene, several derivatives of furan, and the heavily unsaturated alcohol, HC ⋮ C·CH(OH)·CH : CH·Ph, resulting from the interaction of ethynylmagnesium bromide and cinnamaldehyde. An interesting pair of stereoisomers is provided by the low-melting and high-melting forms of 9, 10-dihydroxystearic acid, prepared from oleic and elaidic acids respectively.

The subject index to Volume 39, occupying 34 pages, is a cumulative one, comprising material from volumes 30–39. All the entries in the preceding 29 issues are indexed in Collective Volumes 1, 2, and 3: details of any specific substance are therefore easy to trace. It is almost needless to add that this invaluable series continues to maintain its high reputation for accuracy and reliability. JOHN READ

Glutathione

Edited by E. M. Crook. (Biochemical Society Symposium No. 17, held at Senate House, University of London, February 15, 1958.) Pp. v+116. (Cambridge: At the University Press, 1959.) Cloth 22*s*. 6*d*.; Paper 15*s*.

THE ubiquity of glutathione in living organisms has prompted its widespread study and makes opportune the publication of this symposium, which includes much work carried out after the Ridgefield Symposium of 1953, also entitled "Glutathione". There is no overlap in the contributions to the two symposia, and the present symposium is characteristically different from its predecessor also in presenting a major part of its information in terms of the organisms or organs in which the behaviour of glutathione has been studied. There are considered successively the tissues of plants, of animals, neural tissues, and the lens of the eye. In each of these contributions the reviewers (L. W. Mapson, P. C. Jocelyn, H. McIlwain and S. G. Waley) place their own investigations in a wider setting of the biochemistry of the system concerned. Contributions on the chemistry and analysis of glutathione (F. A. Isherwood, C. G. Thomson and H. Martin) and on its role with other thiols in radiation damage (D. B. Hope) complete the Symposium. It is regretted that there is no index.

COMMUNICATIONS FROM SUPERIOR GALACTIC COMMUNITIES

By Prof. R. N. BRACEWELL
Radioscience Laboratory, Stanford University, California

SINCE Morrison and Cocconi[1] published the suggestion that there might be advanced societies elsewhere in the Galaxy, superior to ourselves in technological development, who are beaming transmissions at us on a frequency of 1,420 Mc./s., Drake[2] has described equipment under construction to look for such transmissions. The confidence necessary to commence actual observations is based on an opinion that planets are a common by-product of the formation of stars. One argument among others is that stars of spectral type later than *F*5 have low angular momenta, just as the Sun has; and in the case of the Sun we know that it is because the momentum (98 per cent of it) resides in planets[3]. Of the thousands of millions of planets in the Galaxy likely to be situated similarly to the Earth in relation to their star, it is hard to dismiss the possibility that some have more advanced civilizations than ours. In view of the acceleration with which technology develops, advanced societies could be incredibly more advanced.

Any simple test of this possibility would be well worth while. Drake plans to look at τ Ceti and ε Eridani. Of the list of likely neighbouring stars given by Morrison and Cocconi, these two, and ε Indi, are the only ones left when we eliminate double stars. Because of orbital perturbations, the planets of double stars are, with some exceptions, not expected to possess equable climates over the geological periods deemed necessary for evolution[4].

But do we really expect a superior community to be on the nearest of those stars which we cannot at the moment positively rule out? Unless superior communities are extremely abundant, is it not more likely that the nearest is situated at least ten times farther off, say, beyond 100 light years? Let us assume that there are one thousand likely stars within the same range as the nearest superior community. This makes it hard for us to select the right one. Furthermore, if this advanced society is looking for us, we can only expect to find them expending such effort as they could afford to expend on the thousand likely stars within the same range of them. It does not seem likely that they would maintain a thousand transmitters at powers well above the megawatt estimated by Drake as a minimum for spanning only 10 light years, and run them for many years, and we could scarcely count on them paying special attention to us. Remember that throughout most of the thousands of millions of years of the Earth's existence such attention would have been fruitless.

Would not this other more advanced society, on the contrary, be doing what we ourselves are now discussing and are on the point of doing, probably during this century, namely, sending probes to nearby stars. Their exploration and other activity would be intense in their immediately neighbouring planetary systems. Beyond their immediate neighbourhood, it might be feasible for them to spray some number of suitable stars, say, one thousand, with modest probes. Each probe would be sent into a circular orbit about one of the thousand stars, at a distance within the habitable zone of temperature. Armoured against meteorites and radiation damage, and stellar powered, the probes could contain durable radio transmitters for the purpose of attracting the attention of technologies such as ours.

Using this plan, our hypothetical advanced neighbours could lay down a stronger signal here than they could with a home-based transmitter handicapped by inverse-square attenuation over interstellar distances. They would also eliminate their dependence on our ingenuity in selecting the right star and the right wave-length.

For this reason we might better devote our efforts to scrutinizing our solar system for signs of probes sent here by our more advanced neighbours. In this way we would be effectively paying attention to all stars capable of reaching us. We need not expect, however, that any community other than the nearest is trying to reach us, because the superior communities throughout the galaxy are probably already linked together into an existing galaxy-wide chain of communication. They will act in concert and avoid duplication in searching. Our impending contact cannot be expected to be the first of its kind; rather it will be our induction into the chain of superior communities, who have had long experience in effecting contacts with emerging communities like ours.

For suggestions as to how the superior communities may detect us, consider what we might do to detect them. A very good first project for us, when we come to probe outside the solar system, would be to seek the presence of technological development on τ Ceti and ε Eridani by means of a probe that would listen for the existence of monochromatic radio-communication, and report back by star-to-star relay. We would see whether there is in those solar systems a radio-frequency line emission spectrum such as the Earth now emits. It is possible, in fact, that the hypothetical feelers sent out in large numbers by our nearest superior community did no more than listen for this radiation. If so, a positive answer could have been on the way back to the home star several decades ago, and we may look forward in due course to the arrival of a more sophisticated mission.

However, since interstellar transfer of material things is time-consuming, and transfer of information is in any event more important, it would be commensurate with the effort of delivering a material probe into our solar system if the very first probe sent here contained a quite elaborate store of information and a complex computer, so that it could not only detect our presence, but could also converse

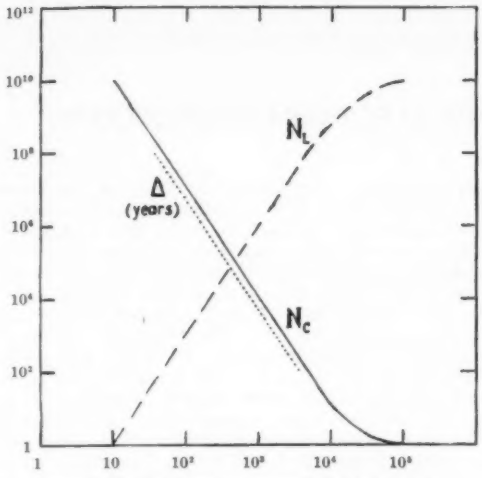

Fig. 1. Nc, total number of communities in the galaxy the technology of which is superior to ours; N_L, total number of likely stars out to a distance d; Δ, average life-time of a superior community

with us. Such a probe may be here now, in our solar system, trying to make its presence known to us. For this purpose a radio transmitter would seem essential. On what wave-length would it transmit, and how should we decode its signal? To ensure use of a wave-length that could both penetrate our ionosphere and be in a band certain to be in use, the probe could first listen for our signals and then repeat them back. To us, its signals would have the appearance of echoes having delays of seconds or minutes, such as were reported thirty years ago by Størmer and van der Pol[5] and never explained.

To notify the probe that we had heard it, we would repeat back to it once again. It would then know that it was in touch with us. After some routine tests to guard against accident, and to test our sensitivity and band-width, it would begin its message, with further occasional interrogation to ensure that it had not set below our horizon. Should we be surprised if the beginning of its message were a television image of a constellation?

These details, and the matter of teaching the probe our language (by transmitting a pictorial dictionary?), are fascinating but present no problems once contact has been made with the probe. The latter is the main problem. The important thing for us is to be alert to the possible interstellar origin of unexpected signals. We must avoid relegating them, if they are there, to the fate of the very strong emissions from Jupiter (of the order of 1,000 megawatts per Mc./s.) which were heard and ignored for decades[6].

If after a few years of careful attention we find no signs, radio or other, of such probe, we shall have to admit the possibility that our nearest superior community is beyond the range where attempts at contact with us would be assured of much certainty of success.

To survey the possibilities of there being a superior community within reaching distance of us, consider Fig. 1, which shows the number of superior communities in the Galaxy, N_C, plotted against the distance to the nearest superior community, d, in light years. This graph is obtained from the broken curve which shows a quantity N_L, the number of likely stars at a range less than d. By likely stars I mean those 5 per cent[4], here taken as 10^{10} in number, that cannot be ruled out at present as unsuitable to support life. The curve is based on a galactic mass distribution model and cannot be considered accurate to better than an order of magnitude.

Now consider the consequences if $N_C = 10^7$. Then $d = 100$ light years, and the number of likely stars within this range is 10^3. The frequency of occurrence, p, of superior communities among likely stars, is 10^{-3}. Although we have no evidence for intelligent life elsewhere, yet if we consider that on the average it takes 5×10^9 years for a likely star to produce one superior community, which then endures for an average life-time Δ measured in years, then $p = 10^{-3}$ implies a Δ of 5×10^6 years, assuming that we are in a state of secular equilibrium. This would seem to offer ample time to explore the 10^3 stars out to 100 light years and establish a chain of communication.

Consider the consequences, however, if technology in our galaxy is less abundant, for example, take $N_C = 10^3$. Then $p = 10^{-7}$, $N_L = 10^7$, $d = 2{,}000$ light years, and $\Delta = 500$ years. The duration of communities which can maintain a frequency of occurrence of only 10^{-7} is thus, on the average, too short to permit interstellar traffic.

If intelligent life does develop on other likely systems at the same tempo as ours has developed, and if some superior community has not made contact with us, it may simply be that the mortality-rate for advanced civilizations is too high for them to become abundant in the Galaxy. Even so, it is rather striking that there would be a thousand superior communities present in the Galaxy at any time even though it takes as long as five thousand million years to produce a technological community that is viable, on the average, for only 500 years beyond the point we have reached.

Even in the event of technology being rare, there is, however, the possibility of a chain existing. Thus, in a Galaxy supporting only 10^3 superior communities with brief expectation of life, there may be some communities that have achieved durability, even quasi-permanence, perhaps by gaining control of the circumstances that lead to short average life-times. Aided by accidental proximity due to random spacing, some of these could be in contact. Presumably such an ancient association would be very able indeed technically, and might seek us out by special means that we cannot guess. Whether they would be interested in rudimentary societies which, in their experience, would usually have burnt themselves out before they could be located and reached, is hard to say. Such communities would be collapsing at the rate of two a year (10^3 in 500 years), and they might already have satisfied their curiosity by archæological inspection made at leisure on sites nearer home. On the other hand, the prospect of catching a technology near its peak might be a strong incentive for them to reach us.

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[2] Drake, F. D., *Sky and Telescope*, **19**, 140 (1959).
[3] Struve, O., *Sky and Telescope*, **19**, 154 (1960).
[4] Huang, S. S., *American Scientist*, **47**, 397 (1959).
[5] Størmer, C., *Nature*, **122**, 681 (1928). van der Pol, B., *Nature*, **122**, 878 (1928). For later discussion, see Budden, K. G., and Yates, G. G., *J. Atmo. Terr. Phys.*, **2**, 272 (1951).
[6] Burke, B. F., and Franklin, K. L., *J. Geophys. Res.*, **60**, 213 (1955). Shain, C. A., *Aust. J. Phys.*, **9**, 61 (1956).

CO-ORDINATION OF LIGHT AND ELECTRON MICROSCOPY

BEING such a complicated and expensive instrument, the electron microscope until recently has remained largely in the hands of physicists. For developing operating techniques, and to a large extent special preparative methods also, this circumstance had distinct advantages, but inevitably it biased the use of the instrument in the direction of high resolving power, of investigating structures and particles (such as viruses) well beyond the limit of the optical microscope. A jump of one hundred times in useful magnification gave some excuse for this attitude, perhaps. There may also have been some tendency to regard electron microscopy as a field of research in its own right, both in biological and metallurgical applications, with the ill-result of detaching it from work done at lower magnifications. Properly seen, of course, it is just another tool of research, albeit a most powerful one, to be used in co-ordination with the established optical and other techniques for investigating microscopical structure. With the gradual realization that it is best situated in the laboratory of the scientist who wants to make use of it—even though it still requires a physicist to bring out all its potentialities—the electron microscope in the past few years has begun to find its way into departments of botany, zoology, metallurgy, and so on. As a result, increasing attention has been given to considering how to correlate its use with other techniques of observation, such as phase-contrast, polarizing and interference microscopy, in addition to X-ray and electron diffraction. It was this trend that prompted the Royal Microscopical Society to approach the Electron Microscope Group of the Institute of Physics, which until now has been responsible for the subject in Britain, to join in organizing a symposium on "The Co-ordination of Light and Electron Microscopy". The meeting was held in the University of Leeds during March 31–April 1. Its timeliness was reflected in an attendance of more than 150, including a number of visitors from Belgium, Holland, Germany and the United States. The proceedings, which will be published in full in the *Journal of the Royal Microscopical Society*, consisted of eight invited papers and a number of short contributions to the discussions on them.

The symposium opened with a detailed review by Dr. R. Barer (Department of Human Anatomy, University of Oxford) of the various methods of microscopy now available. He brought out the range of applicability and the degree to which quantitative information could be obtained with each technique. Prof. I. Manton (Department of Botany, University of Leeds) followed with a talk on the co-ordinated use of electron microscopy and a group of optical techniques in plant cytology, beginning with some remarks on the general difficulties of importing physical methods into a biological laboratory. It is not so much the first cost of an electron microscope as the running costs and the provision of specialist technicians which give trouble. The scale of staffing and expenditure is foreign to the experience of a biologist, and even to a university as a whole, as appeared from later discussion. The best use cannot be made of these new instruments, many of which are bought with grants from trusts and foundations, unless more adequate recurrent funds are made available by universities and the research councils, which ultimately means from government sources. Prof. Manton went on to describe the investigations made in her laboratory into the structure of micro-organisms, and particularly of their cilia. She emphasized the value of light microscopy of specimens dried in a controlled manner, as well as the use of the phase-contrast method for living material. The study of serial sections in the electron microscope may be complemented by through-focal observations in the ultra-violet microscope. Dr. A. D. Greenwood, of the same Department, showed a three-dimensional reproduction of a chloroplast which had been made with the aid of these techniques.

In the afternoon session the use of a selected battery of techniques was further illustrated by Dr. D. Lacy (Department of Zoology, St. Bartholomew's Hospital Medical College, London), on the basis of his own studies of the rat testis, and by Dr. K. M. Rudall (Department of Biomolecular Structure, University of Leeds) in a review of the work done in a number of laboratories on the cross-banding and fine structure of fibres and, in particular, of muscle, nerve, keratin and collagen. Mr. D. H. Page brought a different point of view, in describing the methods developed at the British Paper and Board Research Laboratory, Kenley, for studying the surface of paper and related materials. Ordinary optical techniques are inapplicable, except at low resolution, and transmission electron microscopy is of little help. Much information has been obtained by adapting the shadowcast replica method of electron microscopy to the conditions of optical microscopy. The final replica is embedded in a plastic block, so that the full aperture of the light microscope can be used and high resolution obtained. Much use has also been made of reflexion and scanning electron microscopy, which provide an image with considerable three-dimensional detail at a useful magnification just beyond that of optical methods.

On the following day, a paper by Dr. J. Nutting and Dr. P. Kelly (Department of Metallurgy, University of Cambridge) presented a wide survey of the microscopical techniques used in metallurgy, including X-ray as well as optical and electron methods. The overlapping of their ranges of applicability was displayed by means of a diagram (Fig. 1), in which resolving power is the abscissa and depth of focus the ordinate. Depth of focus is important in metallurgical work, since the relative height of surface features often comes in question. The complementarity of the available methods is well brought out by the diagram. Particular attention was paid to the new techniques developed for observing thin films of metals directly in the electron microscope and to new optical methods for observing slip lines and dislocations. Dr. A. Keller and Mr. D. C. Bassett (H. H. Wills Physics Laboratory, University of

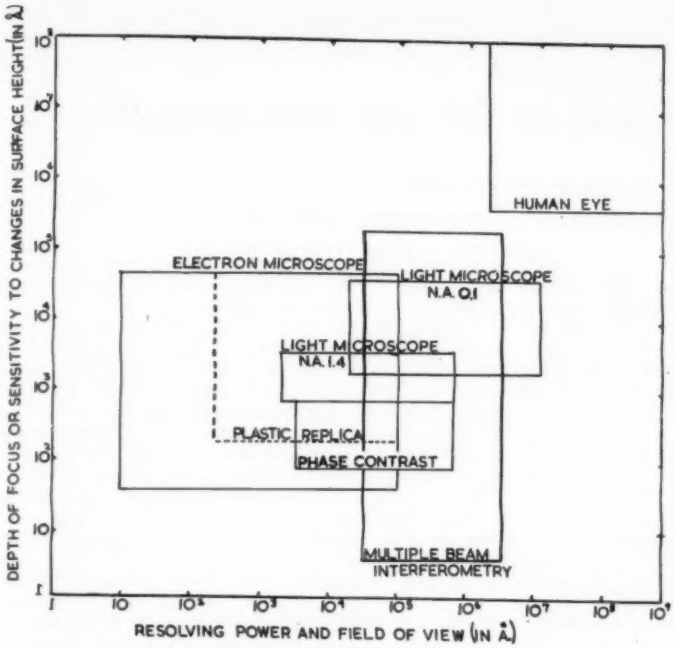
DEPTH OF FOCUS OR SENSITIVITY TO CHANGES IN SURFACE HEIGHT (IN Å)
RESOLVING POWER AND FIELD OF VIEW (IN Å)
HUMAN EYE
ELECTRON MICROSCOPE
LIGHT MICROSCOPE N.A. 0.1
LIGHT MICROSCOPE N.A. 1.4
PLASTIC REPLICA
PHASE CONTRAST
MULTIPLE BEAM INTERFEROMETRY

Fig. 1. Range of applicability of a number of microscopic techniques, in terms of resolving power and depth of focus (after Nutting and Kelly)

Bristol) gave a similar review, though on a narrower front, of light and electron microscope investigations of the habit and structure of crystals, particularly of long-chain polymers. Those of polyethylene are so sensitive to the electron beam that progress has only been possible by careful correlation of optical observations with those made by specially developed electron microscopical techniques at low and intermediate magnifications. The final paper, by Dr. Anna Cosslett (Cavendish Laboratory, University of Cambridge), dealt with the use of some of the optical techniques in association with electron microscopy in a few selected problems, and so far as possible quantitatively, rather than with a broad survey of a branch of science. The ultra-violet microscope at its highest resolving power provides semi-quantitative evidence of the distribution of nucleic acid in chromosomes and micro-organisms, for example, for comparison with the various light and dark regions seen in electron micrographs. The interference microscope can be used to measure the changes in thickness and refractive index of thin sections caused by exposure in the electron beam. In this way the competing effects of loss of material by irradiation and deposition of 'contamination' have been followed in a variety of plastics used for embedding purposes. As much as 50 per cent is lost from some, and 20 per cent from the most resistant, even with an electron dose very small relative to that incurred in normal operation of the microscope.

The main features of the contributions and discussions were summed up by Dr. V. E. Cosslett (Cavendish Laboratory, University of Cambridge). The fruitfulness of a combined attack with all the relevant optical and electron microscopical techniques had been demonstrated in every paper. X-ray methods, which had had little mention, could provide a further dimension in so far as they give information about the nature and amount of the different elements locally present in a specimen. For the most part, light and electron techniques give only the distribution of dry mass, although optical microspectrometry of stained specimens can now explore the localization of particular biological compounds. Optical microscopy will continue to be indispensable in electron microscopy for charting a course through the specimen at the higher available magnification and, even more important, for checking the incidence of artefacts in the various stages in its preparation. At the same time, electron microscopy is beginning to feed back ideas to optical microscopy, in new preparative methods and also in demanding that optical techniques be used to the very best advantage. The standards set by the great light microscopists of the end of the past century are now being re-discovered, and more attention is being paid to teaching the use of the light microscope at high resolution.

Great progress has been made with the electron microscope, since it was invented thirty years ago, but a comparison with the range of optical methods now available brings out how much remains to be done. An electron interference microscope, of limited applicability, has been constructed, but a practicable electron phase-contrast system is not yet in sight. Our electron lenses are still extremely primitive, and, although methods of correction are known in principle, there is a long way to go before a lens corrected for operation at even moderate aperture can be built. The wave-length range available for electron microscopy is barely 1·5 as compared with an optical range of 5 or more. Experimental work at accelerating voltages down to 10 kV. and up to 350 kV. has shown the value of variable wave-length, for image contrast on one hand and specimen penetration on the other; but commercial instruments for the upper and lower ranges are only now being projected. The biggest problem remaining to be solved is that of examining living matter in the electron microscope. Some recent work in Germany and the U.S.S.R. has suggested that this may not be absolutely impossible, as had been thought from the few attempts made in the early days of the subject. It may be that a combination of high-voltage operation with indirect observation at low beam current, using an image intensifier, will allow electron images to be obtained of a limited class of organism and at moderate magnification. Even if we can do no more than follow the effect of radiation damage, this would be of great interest if it is at a resolution appreciably better than that of the light microscope. Such an advance is still many years away, even if it be possible at all. If it is made, then the co-ordinated use of optical and electron microscopical methods will be even more vital than it is in present fields of research.

V. E. COSSLETT

SCIENTIFIC TECHNIQUES IN ART AND ARCHÆOLOGY*

By Dr. A. E. WERNER

Department of Research Laboratory, British Museum, London, W.C.1

IT was in France during the last quarter of the eighteenth century that certain chemists began to apply their specialized knowledge in the field of the fine arts. Their efforts were first directed to the discovery of new artists' pigments. Thus, in 1781, Guyton de Morveau discovered zinc white which he recommended as a new white pigment that would resist the action of sulphurous fumes in urban atmospheres which tended to darken white lead. In his plea to artists to use this pigment, despite the fact that it was more expensive than white lead, he ended his paper to the Academy of Dijon with the phrase: "*On ne marchande pas l'immortalité*"[1]. In 1804 the chemist Chaptal was anxious to find a blue pigment which could be used by the Sèvres porcelain factory in place of the expensive imported ultramarine. He commissioned Thenard to undertake the necessary research, and in a few months he discovered the pigment cobalt blue which now bears his name.

Certain distinguished scientists in Great Britain soon began to follow the example of their colleagues in France. In 1815, Sir Humphry Davy published his classical paper entitled "Some Experiments and Observations on the Colours used in Painting by the Ancients"[2] in which he analysed and identified pigments found at Pompeii, and in 1818 he was commissioned by the Prince Regent to examine manuscripts that had been recovered from Herculaneum in order to find a way of unrolling them without damage[3]. In 1843, Michael Faraday, when lecturing at the Royal Institution, exhibited leather-bound books from the Athenæum Club which were in a very bad state of decay. He correctly attributed this condition to the products of combustion of coal gas and demonstrated that the moisture from a gas flame, condensed on cold metal, contained sulphuric acid. This was the earliest observation concerning the decay of leather by sulphuric acid. In 1853, Faraday served as an expert witness before the Select Committee of the House of Commons which was appointed to inquire into the methods of cleaning paintings being used at the National Gallery at that time.

These examples represent, however, isolated occasions when scientists were called upon to use their specialized knowledge. The intensive application of scientific methods in art and archæology is, on the other hand, of comparatively recent origin.

The work that is carried out in museum laboratories may be considered under three aspects. One is the application of scientific methods to the conservation of works of art and antiquities, the second is the extension of our knowledge about the materials and techniques of painters and craftsmen so as to acquire general information of value to the scholar and art historian, and, thirdly, there is the question of providing objective criteria relating to the authenticity of works of art and antiquities.

Let us consider first of all the use of scientific techniques in the examination of paintings. Normally, one regards a painting from the purely artistic point of view; but, in order to appreciate how scientific methods are employed in the examination of paintings, it is necessary to realize that, from a physical point of view, a painting is a stratified object consisting of four essential layers. These are (starting from the back) the support, the ground, the paint film and the varnish film. In the case of early paintings, the support was usually of wood but, from about the fifteenth century onwards, canvas was used. The ground-layer consisted of a white inert material in a glue medium; in Italy and southern Europe calcined gypsum (hence the word *gesso* often used in describing this layer) was used as the white inert, but in northern Europe it was normally chalk.

Great care was taken by the Old Masters to produce a ground which would have a finished surface that would be as perfect as possible for painting upon; in the words of Cennino Cennini —the famous fifteenth-century writer—it should be "as white as milk (*biancho chome lacte*)" and "smoothed as if it were an ivory (*pulendo si chome fusse uno avorio*)"[4].

The paint film consisted of an aggregate of pigment particles in a binding medium. In so-called tempera painting the medium was egg-yolk, but this was later replaced by various drying oils—the commonest being linseed oil.

The varnish layer was not really an integral part of the painting. It was usually applied after a period of time and served a two-fold purpose; it protected the paint film against atmospheric contamination and restored the original brilliance to those oil paintings which tended to become rather dull in the course of time.

Among the physical techniques used in the investigation of paintings, X-rays are of paramount importance. The degree of absorption of X-rays passing through a painting will depend primarily upon the chemical nature of the pigments present. This can be conveniently expressed in terms of the mass-absorption co-efficient (μ/ρ), the value of which will be greater for pigments containing elements of high atomic weight. Thus, the value for white lead is about ten times greater than that for calcium pigments such as chalk or gypsum. It is fortunate that calcium pigments were used for the ground-layer whereas white lead was extensively used in the actual paint layers. This means that the ground is relatively transparent to X-rays, whereas the paint layers—particularly those areas containing white lead—will be registered in radiographs. The radiographic examination of paintings is not new; in fact, shortly after Röntgen discovered X-rays in 1895, radiographs were being made of paintings. However, improve-

* Substance of a Friday Evening Discourse delivered at the Royal Institution on March 11.

ments in X-ray equipment and a true understanding of the physical factors involved in the X-ray photography of pictures were necessary before the technique could be used to its full advantage[5].

Radiography can often yield information about the technique of an artist. Thus, an X-ray photograph of the painting of "S. Catherine of Alexandria" (National Gallery 168) by Raphael shows that the background (a blue sky) is relatively opaque to X-rays whereas the figure of S. Catherine is more or less transparent to X-rays. This means that the luminosity of the background has been achieved by using a paint containing a large amount of white lead, whereas the luminosity of the figure has been created by allowing the ground to serve as a white reflecting layer which shines through the thinly superimposed layers of flesh paint.

Information can also be obtained which may assist the art-historian in determining the attribution of a painting. Thus in the case of a large altar-piece in the National Gallery originally ascribed to Ercole Grandi (National Gallery 1119) doubts were raised about the attribution. When the Madonna's head was examined, the radiograph showed that the superficial image was very thinly painted and was barely visible, whereas underneath, and posed at a different angle, the original version of the Madonna's head showed up clearly and was obviously painted in a different style. This showed that two artists had been engaged on this altar-piece, and documentary evidence confirmed that this painting was started by the artist Maineri, and finished by Lorenzo Costa. What we see to-day is Costa's version of the Madonna's head which was repainted over Maineri's version, which is visible in the radiograph.

Another physical technique used in the examination of paintings is infra-red photography. Infra-red radiation has a greater penetrating power than visible light so that it can pass through the varnish and uppermost paint layers, and, if the underpaint or ground has a high reflectance coefficient around 8000 Å., it is often possible to reveal *pentimenti* (that is, alterations in composition made by the artist himself) not visible to the naked eye. One rather dramatic example of the success which can be achieved occurred in connexion with van Eyck's well-known painting, "The Marriage of Arnolfini" (National Gallery 186). The artist's first sketch of Arnolfini's right hand as drawn in charcoal on the white chalk ground was clearly revealed beside the final painted version of the hand now visually apparent in the picture. The reason why the initial drawing shows up in the infra-red photograph is that carbon absorbs infra-red radiation whereas chalk reflects it.

Differences in the infra-red reflectance of pigments can often yield information about over-painting. Thus, in a picture by a follower of van der Weyden, "The Exhumation of S. Hubert" (National Gallery 783), the bishop's cope appeared to be painted in a uniform dark blue colour. However, an infra-red photograph revealed an overpainting, which appeared almost black. Subsequent chemical examination showed that the paint in this dark area was a mixture of Prussian blue and chrome yellow. These pigments absorb infra-red radiation to a greater extent than the pigment used in the original paint and hence appear dark against the rest of the cope. This overpainting had been carried out to conceal a hand belonging to the figure standing beside the bishop. When an X-ray examination showed that this hand was, in fact, not badly damaged but was in a good state of preservation, this overpainting was removed and the hand once again revealed as it had been originally painted.

Ultra-violet radiation also can be used for the examination of works of art. Retouchings on paintings and repairs in ceramic or bronze objects are revealed because they show a different fluorescence from that of the background, and in the case of drawings which have faded, fluorescence under ultra-violet may render them visible. Thus, in a collection of drawings by Leonardo da Vinci in the Royal Library at Windsor Castle, there were two sheets upon which very little was visible; but under ultra-violet light they became alive with drawings of hands which were identified as sketches for the "Virgin of the Rocks"[6]. These sketches had been done on a pale pink paper using a soft metal (probably silver) pencil as the drawing instrument. In the course of time the traces of metal were either rubbed off or, possibly, converted into a colourless compound so that the drawing disappeared. However, there still remained enough of the metal to give the characteristic fluorescence under ultra-violet light and bring these sketches miraculously back to life.

Physical techniques give information about the structure of a painting, but chemical—or rather micro-chemical—techniques are concerned with the actual nature of the pigments and binding media used. Precise micro-chemical tests for the identification of pigments have been developed using modern organic reagents for metals in conjunction with Feigl's 'spot test' techniques. Details of the method and typical examples of the reagents used in the National Gallery laboratory have been given by Miss R. J. Plesters[7]. As a natural extension of pigment identification the technique of preparing paint cross-sections has been developed. Minute fragments of paint are embedded in a suitable synthetic resin (for example, polymethyl methacrylate or a cold-setting poly-ester) which is ground down on emery papers until the paint fragment is exposed; the layers of paint can then be examined under the microscope, and information be derived about over-painting and about artists' methods[8].

Recently this technique has been advanced a stage further by Dr. P. Coremans[9], who has succeeded in preparing paint cross-sections which are sufficiently thin (20–30μ) to be viewed under the microscope in transmitted light at a high magnification. Such cross-sections permit a much more precise examination of the structure and composition of the various layers of a painting. Thus, in a fragment of blue paint from van Eyck's "The Mystic Lamb", it was possible to recognize no less than eleven layers; of these, six were authentic van Eyck and consisted of a chalk ground, an isolating layer of oil, three layers of opaque paint containing azurite and lead white in an oil medium and a translucent glaze consisting of natural ultramarine in an aqueous medium, whereas the other five consisted of three layers of varnish between which were sandwiched two layers of repaint containing the modern pigments synthetic ultramarine and Prussian blue.

When compared with the precise tests for the detection of pigments, the methods available for the identification of media were less satisfactory, and were largely based on the comparative behaviour of media towards different solvents. However, the technique of partition chromatography has been successfully applied to this problem and methods

have now been developed in the National Gallery Laboratory[10] for the precise detection of the presence of resins, oil, egg-yolk and glue in paint media.

When one passes from paintings to a study of archæological material, the problems of scientific examination and conservation are quite different. One has to deal with a wide range of objects which differ in their material make-up and are liable to have undergone profound changes while buried in the ground. Methods for the treatment of waterlogged wood, porous ceramic objects saturated with soluble salts, and corroded bronze objects have been recently discussed in *Nature*[11]. Attention will therefore be focused on a few examples selected to illustrate some general principles involved in the examination and treatment of metallic antiquities.

The first example relates to a silver cup which was excavated at Enkomi in Cyprus and was dated about 1400 B.C. This was covered with green corrosion products derived from the copper present in the alloy which had been leached out while the cup was buried. Preliminary examination showed the presence of gold and a black powdery substance which spectrographic analysis showed to be probably a material called *niello* (a mixture of the sulphides of silver and copper). The detection of gold and *niello* suggested the presence of a decorative inlay, and radiography confirmed that this original decoration still survived under the corrosion products. The problem, therefore, was to remove the incrustation and reveal the ornamentation without losing either the gold or the *niello* in the process. Experiments with *niello* prepared in the laboratory showed that this material was unaffected by hot formic acid. This reagent, therefore, was used to remove the unsightly incrustation and the original decoration was revealed in a surprisingly fresh condition[12].

The next example is instructive because it shows that, in the case of iron objects, material which at first appears most unpromising may yield interesting results. A small fragment of a Roman sword of the second century A.D. appeared to have been reduced to a mass of rust. However, radiography revealed evidence of inlays, and, with the X-ray photograph as a guide, the rust was carefully removed to reveal the inlays which had been done in a yellow alloy of copper and zinc (so-called orichalcum). On one side of the fragment there emerged a figure which was identified as the god Mars, and on the other side the Roman eagle with standards.

The conservation of archæological material often presents problems which necessitate the development of a novel technique. Thus, about two years ago an important archæological find was made on the site of a mediæval church in St. Ninian's Island in the Shetlands. This consisted of twenty-eight metal objects thought to be early Christian in origin and to date from about A.D. 800. These objects were regarded by the excavators as bronze, but examination showed that the metal was, in fact, a base silver alloy containing much copper which had mineralized during the years of burial to form a thick coating of copper corrosion products. The most interesting item in this hoard was a composite object thought to be a hanging bowl with an internal liner. This supposed liner was soon found to be a separate decorated bowl, which had been pushed into the hanging bowl, and it was easily removed and cleaned. The hanging bowl itself was of particular archæological significance, because it is the only known surviving example of a *silver* hanging bowl to have been found in Britain. Its conservation presented a problem of peculiar interest[13]. The strength of the bowl was due almost entirely to the layers of corrosion products, between which egg-shell thin silver was sandwiched; but at the same time it was considered necessary to remove this incrustation because it was unsightly and gave a false impression of the original appearance of the bowl. When cleaned, the hanging bowl was therefore extremely fragile, so that it was necessary to devise some form of internal support to act as a permanent reinforcement. After a series of trial experiments, a cold-setting epoxy resin ('Araldite' casting resin *F*) was chosen because it adheres well to metal, is transparent, and sets without appreciable shrinkage. A viscous mixture of resin and hardener (together with dibutyl phthalate as plasticiser) was brushed uniformly over the inside of the bowl, which was rotated on a small turntable so as to keep the resin mixture uniformly distributed while it set. In this way it was thus possible to reinforce the bowl with a thin transparent film which gave sufficient mechanical strength so that the bowl could be handled with perfect safety.

When scientific methods are used in connexion with the authenticity of antiquities, the evidence obtained may be either positive or negative. In the former case, the evidence will indicate the approximate age or the definite antiquity of the material of which the object is made, thus establishing probable authenticity. In the latter case, one seeks evidence of anachronisms in the use of materials or techniques which prove that the object could not belong to the period assigned to it.

In order to appreciate how varied are the scientific methods that can be used in this field, it is of interest to mention a new technique which was developed at the Leather Industries Department of the University of Leeds to confirm the alleged age of the Dead Sea parchment scrolls. The first step was to take photographs with the electron microscope to show how the actual collagen fibres had undergone a characteristic degradation due to the long sojourn of the scrolls in the dry atmosphere of the caves in which they had been discovered. Then, the decrease in the shrinkage temperature of small fibres teased out from the scrolls was measured, and, by comparing the value found with that of parchments of known date, it was possible to arrive at an approximate age of about two thousand years for the Dead Sea scrolls[14].

In the case of metal objects, a metallographic examination, both of the corrosion products and of the metal remaining beneath the corrosion layers, may provide manifestations of antiquity. It will, however, be impossible to give even an approximate age, because the rate at which a metal corrodes will be greatly influenced by its environment.

Genuine patinas are minerals that have slowly grown on the surface of the metal, and under high magnification they will usually show a complex banded structure and inter-crystalline penetration into the metal leading to replacement of metal crystals by mineral, that is, pseudomorphism. On the other hand, false patinas which are induced by accelerated corrosion can be distinguished by the fact that they tend to be on a much smaller scale, do not usually show the banded structure or penetrate into the metal. A metallographic study of cross-sections of patinas, particularly in the case of bronze objects, may, therefore, yield conclusive evidence either for or against antiquity.

In the case of silver objects, a study of the metal itself may be very informative. Ancient silver acquires a crystalline quality—the characteristic property that accounts for its brittleness. Fractures in the surface of the metal may look lined and decayed like old leather, and granular crystals are often visible.

In contrast to this a technical examination of a silver plate in Bactrian style (second to first century B.C.) revealed features which cast serious doubt on its authenticity. A photomicrograph of dents in the edge of the plate and scratches on the surface showed the silver to be in a ductile condition, and there was no evidence of crystallization. Moreover, when struck, the silver rang like a bell quite unlike the dead response given by highly crystallized silver. Also, the foot rim was in an almost virgin condition and showed no signs of wear; in an object of the presumed age of this plate, which weighed 1,128·5 gm., one would normally expect to find signs of wear visible to the naked eye. In this case none was visible even under the microscope. Another odd feature was the absence of silver chloride—the typical corrosion product of silver to be expected from the presumed environment. These findings were confirmed when the models which served for the design on the plate were traced to a manuscript of the "Fables of Bidpai" in the Yildiz Library at Istanbul[15].

In the scientific examination of paintings of doubtful authenticity one is concerned either with the possible discovery of anachronisms in the use of pigments and media or with abnormalities in technique. Three examples will show how this kind of evidence can be used to detect forgeries. In the case of a painting of a "Laughing Cavalier" attributed to Franz Hals, microchemical examination of fragments of *original* paint revealed the presence of no less than three pigments—synthetic ultramarine, zinc white, and cobalt blue—which were unknown in Franz Hals's time. The presence of these pigments constitutes undoubted proof that this painting could not be by the hand of Franz Hals.

The next example is the famous forgery case which shook the art world on July 12, 1945, when the Dutch artist, van Meegeren, claimed he had painted certain pictures which had been attributed to Vermeer —the most famous of which was the "Christ with the Disciples at Emmaus"[16]. Microchemical tests revealed many facts which clearly showed that these paintings were indeed fakes. Thus, the medium proved to be a modern synthetic phenol–formaldehyde resin, traces of the pigment cobalt blue were found in samples of blue paint, and the dirt in the craquelure—that network of fine cracks which is to be seen on all old paintings—proved to be ordinary indian ink which, moreover, had in places seeped into the porous medium, thus blurring the sharp outline of the cracks, and giving them a very suspicious appearance.

It is also possible to use radiography to unearth further scientific evidence. Since potential buyers of Old Master paintings are always impressed by signs of age in the support, it is a common practice among fakers to use authentic old supports upon which to perpetrate their forgeries. In this particular case, van Meegeren bought seventeenth-century paintings by minor Dutch artists and scraped off as much as he could of the paint so that he had a suitable canvas upon which he could proceed to paint his pseudo-Vermeer pictures.

It is, however, very difficult to remove completely all traces of the original painting, and therefore, when X-ray photographs of these suspected paintings were taken, it was possible in all cases to detect traces of some different painting lying beneath the superficial image. In the case of one of these pseudo-Vermeers representing "The Last Supper", the radiograph showed the distinct outline of dogs and birds. A Dutch art dealer had fortunately kept a photograph of a painting of "A Hunting Scene" by Hondius which van Meegeren had bought from him in 1938. When this photograph was compared with the above radiograph, there could be no doubt whatever that the pseudo-Vermeer "The Last Supper" had been painted over what had once been the Hondius "Hunting Scene".

The techniques mentioned so far can only be applied to detecting forgeries of Old Master paintings. When the question arises of detecting a forgery by a modern artist, anachronisms in the actual materials will obviously not apply. It is necessary instead to obtain evidence about the actual technique of the artist so that it may be compared with the technique of the suspected painting. This can often be achieved by radiography. It was successfully used to unmask a number of van Gogh forgeries which came to light in 1928. When X-ray photographs were taken of these paintings, a striking difference was found between the radiographs of the suspected paintings and the radiographs of genuine van Gogh paintings. The latter showed the powerful brush strokes which give van Gogh paintings their rhythm and true meaning. On the other hand, the radiographs of the forgeries showed the restless nervous brush strokes of the faker, who had merely succeeded in imitating the characteristic superficial appearance of van Gogh paintings.

This account of the kind of work carried out in a scientific department attached to a museum or art gallery will show that the work is very varied, both as regards the type of problems—whether of conservation or scientific examination—and the methods which are brought into play to solve them. The scientist is often accused of indulging his idle curiosity, and at first his intrusion into the museum and art gallery may perhaps have been viewed by the scholar with a certain amount of alarm. However, the position has now happily arisen in which there is active and intimate co-operation between the scientist and the scholar in the study of problems of mutual interest. In this field it can be justly claimed that a successful attempt has been made to bridge the gap which has sometimes been presumed to separate science and art.

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OBITUARIES

Prof. E. G. Richardson

Edward Gick Richardson, who died on March 31 at the age of sixty-three, was well known, not only in Great Britain, but also internationally, for his work in acoustics and ultrasonics.

He took the degree course in physics at East London (now Queen Mary) College, graduating during the First World War. He then served in the Royal Air Force (Balloon Section), which no doubt initiated his life-long interest in aerodynamics and meteorology. After a short period as a grammar school master, he undertook research at East London College under Prof. C. H. Lees. About two years later he was appointed a lecturer at University College, London, and during the next seven years his research work in acoustics, recognized by the award of a D.Sc., firmly laid the foundation of his subsequent reputation. In 1931 he moved to King's College, Newcastle upon Tyne, where he spent the rest of his life; he was made a reader in 1943, and in 1956 a chair in acoustics was created for him.

Richardson's research achievement was so extensive and diverse that no brief summary is possible. It must suffice to say that he published some ninety papers on a wide variety of topics, including, besides acoustics and ultrasonics, liquid jets and suspensions, viscosity, hot-wire anemometry and viscometry, atmospheric turbulence, relaxation processes and fish locomotion. In acoustics he made notable contributions to many branches; among these the best-known are probably the absorption of sound in vapours and narrow tubes, phonetics and speech analysis, and æolian, edge and transient tones. In later years he turned his attention to ultrasonics, with special reference to absorption and dispersion. In these researches he was often assisted by students, many of them from overseas, who owe much to his help and encouragement. His experimental work was characterized by directness of attack and economy of means, and he was particularly interested in new lines of investigation. He opened up many of these, leaving others to explore the territory which his work had made accessible.

In addition to his research work, Richardson found time to write upwards of a dozen books, including several compilations which he edited or to which he contributed sections. The most widely known are probably "Sound" (a very popular textbook), "The Acoustics of Orchestral Instruments", "Acoustics for Architects" and "Physical Science in Art and Industry". He wrote fluently and well, with an admirable clarity of expression and an easy mastery of his subject. He was English editor of the international journal *Acustica*, in the founding of which he played a prominent part.

He received numerous invitations to lecture abroad, and did so in the United States (several times), Canada, India and most countries of Europe. He was visiting professor of physics at the University of Cairo for a term in 1947, and a Leverhulme Fellow during 1955–57. During the Second World War he served as scientific adviser from early 1940, first in the Admiralty (Mine Design Department) and later in the Air Ministry (Royal Aircraft Establishment and Helensburgh). After returning to King's College he carried out various research contracts for these Ministries.

Although Richardson's primary interest was research it was by no means his only one, for he was an accomplished musician, a dedicated cyclist, and an indefatigable member of the College Country Dancing Club. He played both piano and organ well, and for many years travelled between Durham and Newcastle twice daily on Sundays (some sixty miles in all) in order to sing in the Cathedral choir. He was a deeply religious man, although none but his closest friends would be aware of this, for he was somewhat shy and reticent by nature. Nevertheless, his sterling qualities of modesty, sincerity and kindliness were apparent to all who knew him, and endeared him the more the better one knew him. His sudden death was a great shock to all his friends; they will long bear him in affectionate memory.

W. E. Curtis

Dr. John Duckworth

The sudden death on April 11 of Dr. John Duckworth, head of the Applied Biochemistry Department of the Rowett Research Institute, Aberdeen, has robbed the science of food and agriculture of an outstanding investigator.

Born in Manchester but educated in Canada, and in the course of his life conducting research in Canada, Trinidad and Guatemala, he spent about a quarter of a century in the service of the Rowett Institute at Aberdeen. He obtained his original training at the Ontario Agricultural College, Guelph, and took the degree of B.S.A. at the University of Toronto. He next spent a year with Lever Brothers, Ltd., in Toronto, as analytical chemist, and another year with the same firm's economics section studying production efficiency. In 1931 he became assistant to the professor of chemistry at Macdonald College, McGill University, where he carried out research on the blood chemistry of cattle afflicted with genital disease, and on contagious abortion in cattle.

In 1933, Dr. Duckworth came to the Rowett Institute, where he investigated the relationship of nutrition to pathological conditions in farm animals. He also worked on the partition of serum calcium and the factors affecting it. The object was to establish a closer relationship between the blood picture and the evidence of certain types of disease, such as milk fever and rickets, in farm stock. The latter work was incorporated into a thesis, for which the University of Aberdeen awarded him the degree of D.Sc.

Later he investigated magnesium metabolism in animals, and the influence of fibre in the diet on the utilization of protein and calcium. He collaborated in work on problems connected with both human and animal nutrition, for example, the utilization of phytic acid phosphorus in oatmeal by men and farm animals.

In April 1944 he was appointed senior lecturer in the Agricultural Department of the Imperial College of Tropical Agriculture, Trinidad. There he developed courses of instruction in animal husbandry, and created a nutrition laboratory for investigation of the

value of various feeding stuffs under tropical conditions.

In September 1946 he returned to the Rowett Institute, and three years later became head of the Department of Applied Biochemistry. His work concerned protein and vitamin requirements, energy needs and metabolism, and mineral metabolism and requirements. He also developed chemical tests which might be correlated with the biological value of proteins. With Mr. N. W. Pirie, of Rothamsted Experimental Station, biological tests had been made on leaf protein for non-ruminants.

Duckworth was responsible, with the Institute's X-ray Section, for developing a mobile X-ray unit for the outdoor study of hill sheep in relation to calcium and phosphorus requirements. In his Department the role of copper in the ruminant was also under investigation, and much progress was being made in the elucidation of this problem.

In 1954, Dr. Duckworth was elected a Fellow of the Royal Society of Edinburgh, and in 1955 was one of four British scientists who attended a symposium of Europe's leading agricultural research experts in Rome, sponsored by the Pfizer Agricultural Research Institute of America, for discussion of research into the use of antibiotics and other new growth factors in animal nutrition. Later in the same year, he was one of three British experts invited to an international conference in Washington on the same subject.

From August 1956 until August 1957, he was seconded to the Food and Agriculture Organization of the United Nations and the United Nations Children's Fund, to assist the Governments of Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama on food and nutrition policy. With Señorita E. Musmanno of Argentina, he collected statistics of the countries' food production, which showed that between 6 and 10 per cent of their population were dependent on outside sources of food supply. If one took into account the rate of growth of the population, it appeared to be necessary to double food production in the next twenty-five years, and to alter the balance between cereal and livestock production in favour of the latter. Due account was taken of the actual situation in the area : for example, cattle and sheep raising was to be based on native stock feeding on grass, rather than on imported stock eating concentrate feeding stuffs, at least in the early stages. The need was stressed for modern factories for milk and meat products. Almost his last task was to check the Spanish edition of their second report on the area.

Dr. Duckworth was an enterprising yet meticulous experimenter, a skilled statistician and planner, an arresting and clear expositor of his researches, and one who knew the agricultural industry as few others. He was a lively conversationalist and good pianist. He is survived by his wife, and a son and daughter.

D. P. Cuthbertson

Prof. K. W. Szarski

The death of Prof. Kasmierz Witalis Szarski on January 18 prematurely severed a life of great service to zoology and Polish universities. He was born in Vienna in 1904 and on the family's removal to Lwöw attended school and the University there. He took his doctorate, and seven years later (1939) became *docent* in comparative anatomy. Soon afterwards the Russians occupied the University and demoted the staff. Later, under Nazism, academic work ceased, but by acting as hosts for lice used in preparing Prof. Weigl's anti-typhus vaccine, Szarski and colleagues slightly eased impoverishment and received certification as persons usefully employed. Afterwards he and his wife were arrested in Warsaw, but by mere chance escaped transportation to Nazi concentration camps and secured release, he being directed to vitamin investigations.

When war ended, Szarski became professor of comparative anatomy at Wrocław, the new setting for the University of Lwöw—Polish no longer. Amid the devastation of Wrocław half the zoological institute lay ruined and in its and the University's rehabilitation Szarski played a leading part, particularly as pro-rector and rector (1954–59).

Szarski was a born naturalist. His early researches related principally to developmental anatomy : three long papers on the urogenital systems of mice being authoritative. His post-war work mainly comprised ornithology and translation. His account of the birds adopting residential niches in the mountainous ruins of Wrocław is fascinating. Freed from rectorial labours, he turned eagerly to study the avian brain—promising work cut short by his death. His comprehensive learning in zoology and his command of Slav and European languages—especially English, French and German, fitted him perfectly as counsellor, editor and translator in many professional capacities. His notable translations, with scholarly commentaries, comprise Darwin's "Voyage of the Beagle" (two editions) and Darwin's and Wallace's historic essays on natural selection (Linnaean Society of London). He was deservedly honoured when chosen to deliver the Darwin Centenary Lecture to the 1959 Polish Zoological Congress in Cracow—practically his last service to science.

Szarski was small and delicate-looking ; of great culture, wit, sensitivity and charm ; unpretentious ; of highest integrity, with an over-riding sense of duty that over-taxed his strength. He had courage : during the Warsaw rising a young insurgent refugee to Szarski's lodging owed his life to Szarski's bluffing of a *Luftwaffe* search-party. He won friendship everywhere : his students and colleagues speak of him as truly 'nieodzalowany' (never to be sufficiently mourned).

Two recent working visits to England gave Szarski renewed inspiration ; in Poland British zoologists have profited by his collaboration and enjoyed the bright hospitality of Pani Szarski, himself, and their young daughter, in their modest flat high above the Oder.

In preparing this notice I am indebted to Mr. W. Rybotychi of London, Prof. Sembrat of Wrocław and Prof. Henryk Szarski, rector of the University of Torun.

A. D. Peacock

Prof. Ramesh Chandra Ray

Ramesh Chandra Ray was born in 1890 and took the degree of M.Sc. from the Presidency College, Calcutta, in 1911. He was one of the first students of the Indian Institute of Science, Bangalore, where he worked with Travers on boron compounds formed by the decomposition of magnesium boride. In 1915 he was appointed professor of chemistry at Patna College and, after the War, joined Donnan's laboratory at University College, London, where he

continued his work on boron compounds. He succeeded in preparing borohydrates and in establishing the existence of hitherto unknown oxides of boron. For his work on this complicated system he was awarded the D.Sc. of the University of London. He also obtained the fellowship of the Royal Institute of Chemistry.

Returning to Patna, he was responsible for creating a school of research which produced a steady output of papers on inorganic chemistry. The majority of these dealt with boron compounds and formed a valuable contribution to the chemistry of that element. In 1940 he was appointed head of the Department of Chemistry, and in all he worked for thirty-five years at the College. His outside interests were extensive, even after retirement; he was chemical adviser to the Government of Bihar, chairman of the examination board of Bihar University, founder-rector of the Ram Mohun Roy Institute and president of the Manorma Vidyapith. In 1944 he was elected president of the Chemistry Section of the Indian Science Congress.

He died on December 3 and leaves a widow, four sons and three daughters.

NEWS and VIEWS

Electrical Engineering at Cambridge : Prof. E. B. Moullin

Prof. E. B. Moullin retires from the chair of electrical engineering at Cambridge on September 30. Thus will end his official connexion with the Engineering Laboratory, which he first entered in 1913. In that year he began to read for the Mechanical Sciences Tripos, having previously taken Part I of the Mathematical Tripos. After a short period in industry, Moullin returned to a lectureship in engineering at Cambridge which he held until 1929. It was during this period that he developed the valve voltmeter associated with his name, and carried out numerous researches in collaboration with L. B. Turner. In 1930 he migrated to Oxford where he held the Donald Pollock readership in engineering science until 1945. Here, his scientific approach to electrical engineering problems attracted numerous research students, several of whom have since achieved world-wide recognition. Moullin was elected to a fellowship at Magdalen in 1932. During the Second World War he worked first at the Admiralty Signals Establishment and later in the research laboratories of Metropolitan-Vickers. In 1945 he returned to Cambridge as the first occupant of the newly created chair of electrical engineering and was elected to a fellowship at King's College. For many years Moullin has taken an active part in the affairs of the Institution of Electrical Engineers. He was chairman of the Radio Section in 1939 and president of the Institution in 1949. He is the author of a number of successful text-books which are distinguished by a freshness and individuality of outlook. His scientific writings cover a wide range of subjects but are largely concerned with problems in electromagnetic theory. The honorary degree of LL.D. was conferred on him by the University of Glasgow in 1958.

Prof. C. W. Oatley

C. W. Oatley, who succeeds Prof. Moullin in the chair of Electrical Engineering at Cambridge on October 1, was educated at Bedford Modern School and St. John's College, Cambridge. He read both parts of the Natural Sciences Tripos, specializing in physics, and graduated in 1925. After a short spell in the radio-valve industry he was appointed to a demonstratorship in the Physics Department of King's College, London, where he worked under Sir Edward Appleton and later under Sir Charles Ellis, until the outbreak of war. During this period his interests were centred on various problems of electron physics, particularly those concerned with the measurement and interpretation of the contact potential difference between metals. In 1939, Oatley joined the Air Defence Experimental Establishment of the Ministry of Supply, then situated at Christchurch. There he took charge of a group working on radar receivers and became especially interested in ultra-high frequency and microwave measurements. In 1942, when the Establishment moved to Malvern and became the Radar Research and Development Establishment, Oatley was responsible for all basic research work. A year later he became deputy to the Chief Superintendent and, during 1944–45, was in charge of all technical work in the Establishment. In 1945 he returned to Cambridge with a lectureship in the Department of Engineering and a fellowship at Trinity College. During the past fifteen years he has been active in building up research work in electronics and has become interested in problems of electron microscopy. He was appointed to a readership in 1954. Since the War he has had close connexion with the work of the Institution of Electrical Engineers. He served on the Radio Section Committee for a number of years and was chairman of the Section in 1954.

Chemistry at Aberystwyth : Prof. C. W. Davies

Prof. C. W. Davies, who is retiring from the chair of chemistry in the University College of Wales, Aberystwyth, is well known for his many contributions to electrochemistry extending over an active research career of more than thirty years. Prof. Davies early became interested in the conductivity of electrolytes, and at the appearance of the Debye–Hückel theory he was among the first to suggest the combination of the law of mass action with the ionic interaction theory to account for the conductivity of strong electrolytes. He showed that the dependence on concentration of the conductivity of many electrolytes could be accounted for if they were incompletely dissociated in solution. This conclusion was not at first readily accepted, because to many chemists the Debye–Hückel theory implied complete dissociation of all electrolytes. The idea that salts are completely dissociated in solution, and that variations in conductivity are due to variations in mobility, was too simple and attractive to be readily abandoned. This difficulty of acceptance was increased by the fact that the physical interpretation of incomplete dissociation was rather obscure. However, Prof. Davies and his collaborators showed that measurements of conductivity and of solubility led to results for dissociation constants of salts in good agreement with one another. Kinetic studies, too, have given

results which can only be explained by incomplete dissociation. Apart from the important idea of incomplete dissociation and its careful experimental support, Prof. Davies's other main contribution to electrochemistry was his book, "The Conductivity of Solutions", published in 1929 and in 1933. His more recent work in the field includes studies of the polyphosphate ions in solution, as examples of ions with high negative charges, and the use of ion-exchange resins in electrochemistry. In addition to his personal researches, he has played a major part in building up the Chemistry Department at Aberystwyth to achieve its present reputation as an active centre in physical chemistry.

Prof. A. F. Trotman-Dickenson

Dr. A. F. Trotman-Dickenson, who has been appointed to succeed Prof. Davies, is at present lecturer in chemistry in the University of Edinburgh. In the course of a research career of more than ten years, he has made several important contributions to chemical kinetics, chiefly to the study of elementary reactions in gases. His work with Dr. E. W. R. Steacie at the National Research Council in Canada on the reactions of methyl radicals gave information about the rates with which these radicals abstract hydrogen from a wide range of compounds. Dr. Trotman-Dickenson has studied the abstraction, decomposition and disproportionation reactions of many alkyl radicals and has obtained an important body of new information. In collaboration with Dr. J. H. Knox, he has developed competitive methods for obtaining relative rates of reaction of halogen atoms with various alkanes and has extended such methods to the study of oxidation. He has made contributions to the study of the reactions of the methylene radical. In yet another recent series of experiments, Dr. Trotman-Dickenson has determined several carbon–metal bond-strengths by kinetic methods. In addition to his main work on elementary reactions Dr. Trotman-Dickenson, along with Drs. H. O. Pritchard and R. G. Sowden at Manchester, has made a most important detailed investigation of the effect of added gases on the rate of isomerization of *cyclo*-propane; this gave valuable information about energy transfer to reacting molecules. His book, "Gas Kinetics", published in 1954, is a useful survey of this branch of chemistry, and his recent monograph, "Free Radicals", is a valuable introductory text.

Agricultural Sciences in the Rockefeller Foundation : Dr. A. H. Moseman

Dr. Albert H. Moseman has been appointed director for the agricultural sciences in the Rockefeller Foundation. Dr. Moseman went to the Rockefeller Foundation in 1956 as associate director for the agricultural sciences. Previously he was director of crops research of the Agricultural Research Service of the U.S. Department of Agriculture. He was born in Oakland, Nebraska, received the B.S. and M.S. degrees from the University of Nebraska and the Ph.D. degree in plant breeding and genetics from the University of Minnesota. He served on the mission which helped plan the Point IV programme in agriculture, and was a member of the joint Indo-American team which developed recommendations to the Government of India for improvements in agricultural research and education. The University of Minnesota conferred its Outstanding Achievement Award on Dr. Moseman in 1958.

Biology at Oregon : Prof. G. Streisinger

Dr. George Streisinger has been appointed associate professor of biology in the Institute of Molecular Biology at the University of Oregon as from September 1. Prof. Streisinger is at present at the Carnegie Institution of Washington, Department of Genetics, Cold Spring Harbor, New York. He took his Ph.D. degree in bacteriology at the University of Illinois, and was a post-doctoral fellow of the National Foundation for Infantile Paralysis at the California Institute of Technology. He spent the year 1957–58 working with Dr. Francis Crick in the Cavendish Laboratory, Cambridge. Dr. Streisinger's principal research interest at present is in the relationship between the structure of a protein (bacteriophage lysozyme) and the structure of the gene which controls its formation.

Experimental Biology at Rehovoth, Israel : Prof. J. Berenblum

The establishment of the Jack Cotton research professorship of experimental biology at the Weizmann Institute of Science, Rehovoth, Israel, will help to consolidate and further the work carried out in the Department of Experimental Biology at the Institute. The first holder of the chair will be Prof. I. Berenblum, who has been in charge of the Department since its inception in 1950. This Department comprises a number of sections in different branches of biology and experimental medicine, several of them connected with cancer research—the field of Prof. Berenblum's own specialization. Prof. Berenblum is a graduate of the University of Leeds, a former Beit Memorial Research Fellow (at the Dunn School of Pathology, University of Oxford), and at one time in charge of the Oxford University Research Centre of the British Empire Cancer Campaign. His field of research has been mainly concerned with the 'two-stage mechanism' of carcinogenesis. The proposed expanded programme of research, aided by the munificent gift of Mr. Jack Cotton, will entail the expansion of the work on the two-stage mechanism of carcinogenesis, with particular emphasis on the biological and biochemical role of urethane in the two-stage process, and the extension of the principle to systems other than the skin, including its recently discovered role in leukæmogenesis. The recent addition of further animal buildings, X-ray equipment, and the intended expansion of its biochemical facilities, will further the projected expansion of the research programme.

Amalgamation of the Institute of Physics and the Physical Society

The Institute of Physics and the Physical Society have amalgamated and the new body will be known as "The Institute of Physics and the Physical Society". The first president of the amalgamated body is Sir John Cockcroft, and the four vice-presidents are Dr. J. Topping, Dr. W. H. Taylor, Prof. R. W. Ditchburn and Mr. A. J. Philpot, each responsible to the Council for a defined area of the many activities to be taken over by the new organization from its predecessors. The presidents of the original bodies, Sir George Thomson and Mr. J. A. Ratcliffe, are also members of the new Council. The other officers are Dr. J. Taylor (honorary treasurer) and Dr. C. G. Wynne (honorary secretary).

The Physical Society of London, as it was then called, was founded in 1874, and on the initiative of

that Society's Council, the Institute of Physics was founded forty-five years later. The original scheme envisaged a kind of federation of societies interested in physics, to provide, among other objects, rooms for meetings, a library, and a common secretariat. In fact, the Institute's offices were in the Society's present rooms in South Kensington during 1927–49, and the Institute provided the secretariat for the Physical Society and the Optical Society, which themselves amalgamated in 1931. Broadly speaking, before the War the scientific meetings and publications of the Institute were confined to applied physics, while those of the Society were concerned more with pure physics. As, however, the boundary between these two aspects became less definite there has been increasing overlap in the activities of the two bodies and in their membership. It is not, therefore, surprising that during the past twenty years proposals for the amalgamation of the two bodies have been made repeatedly, and from time to time detailed proposals examined, until eventually a satisfactory solution was worked out. The executive officers of the new body are: *Secretary*, Dr. H. R. Lang; *Editor and Deputy Secretary*, Dr. A. C. Stickland; *Deputy Secretary*, Mr. N. Clarke. The registered offices and headquarters are at 47 Belgrave Square, London, S.W.1, and for the present, offices will also be retained at 1 Lowther Gardens, South Kensington, London, S.W.7.

University of Toronto Computation Centre

The Board of Governors of the University of Toronto has approved the proposal to construct, install and operate a copy of *Illiac II* as the major computing facility in the Computation Centre at the University of Toronto. This project is financed in part by a grant of 600,000 dollars from the National Research Council of Canada and the Sir Frederick Banting Fund. *Illiac II* is the high-speed computing machine now being constructed at the Digital Computing Laboratory of the University of Illinois. In it, solid-state devices are used as the main electronic parts. It is designed to be a very reliable and easily serviced machine. Its logical design is elaborate, novel and very efficient in large calculations. The construction at Toronto will be under the supervision of Profs. R. W. McKay and C. C. Gotlieb, who have been associated with the work at Illinois for the past four years. The University of Toronto plans provide special accommodation for the Centre in the new Physics Building to be occupied, it is hoped, in 1962.

Appointments in Industry and Commerce

The annual report for 1959 of the Committee for Appointments, published in a supplement to the *Oxford University Gazette* of March 14, records that of 8,792 vacancies, 5,545 called for men with scientific qualifications, an increase of 2 per cent on the previous year, compared with 11·6 per cent increase in the demand for arts men for industry and commerce. Discussing the effect on graduate employment of the bulge in school population and of the trend to stay on in sixth forms of grammar and public schools, the report stresses the need to convince industrial firms that universities really are creaming off the best of the sixth-form leavers even when university places cannot keep pace with the rise in numbers of sixth formers who are up to normal entrance standards and when sandwich courses are very attractive to parents. Meanwhile, it is apparent that there are far too many mediocre graduates on the market, and three-quarters of the engineering graduates entering the engineering industry make competent specialized technical men but are not up to leading teams in difficult times. The emphasis in recruitment must be on good engineers who can handle people, practical men who can get results from engineering ideas, and the Committee suggests that if the universities cannot prove that such are their products, industry could lose much of its interest in graduates. It is also suggested that there may be a tendency in some firms to concentrate, up to 1965, on school-leavers to the exclusion or partial exclusion of graduates. The school-leaver is refreshingly attractive, being eager to get going in a job, lively, enthusiastic, not choosy, and in contrast with graduates who have been generally cosseted in choosiness and superficial indifference and an attitude suspiciously near that of "the world owes me a living". Pointing out that if the effect of the bulge and trend ultimately is to compel graduates to try harder to secure an appropriate job, graduates will benefit, and commenting on "the dreary procession of would-be B.Sc.'s" seen each year by industrial recruiters, the report suggests that sixth formers may constitute formidable competition in that they will have had two or three years experience.

Choosing a Career

To help young people in their choice of a career, some twelve years ago the Central Youth Employment Executive of the Ministry of Labour and National Service began a series of publications designed to give information about various occupations and the opportunities they provide entitled "Choice of Careers". The series has been remarkably successful and, altogether, 163 editions, many of them revisions of earlier issues, have been published. Total sales of all editions have been well over a million. To mark the issue of the 100th booklet, which is called "The Scientist", the Central Youth Employment Executive has reprinted the first booklet, "Choosing your Career", which deals with the fundamental questions which young people need to pose before selecting a particular occupation in which they intend to pursue a career (Choice of Careers Series No. 1. Pp. 32. 1*s*. 6*d*. net). Another booklet, "Laboratory Technicians and Assistants", is even more profusely illustrated and contains much information about an assistant's job in the laboratory (Choice of Careers Series No. 94. Pp. 56. 2*s*. 6*d*. net). It is surprising, therefore, that "The Scientist" should be produced with such little imagination and launched at half the cost of "Laboratory Technicians and Assistants" (Choice of Careers Series No. 100. Pp. 48. 1*s*. 3*d*. net). The text seems designed to show that the scientist's highest ambition should be to become a 'backroom boy' while, if he turns to industry, he may find jobs in plant management provided he is prepared to give 'technical guidance' in running the plant and not wish to accept "direct responsibility for production management". Little reference is made to the scientific training which our future administrators will need. The tone of the booklet appears to indicate that Whitehall is still controlled by men who believe that men of science can perform useful supporting roles as technical experts, but that direction should rest with men trained in the liberal arts. Forthcoming booklets in the series are to be "Mathematics" and "Applied Science and Technology". The booklets are obtainable from H.M. Stationery Office.

British Water Research Association

THE fourth annual report of the Water Research Association covers the year ended June 30, 1959, and includes the reports of the Council and of the director of research, Dr. R. G. Allen, together with lists of staff and of members (pp. 31+4 plates. Redhill: Water Research Association, 1959). The Association's application for a grant from the Department of Scientific and Industrial Research was approved in February for the five years commencing 1959, at £15,000 a year, conditional on a minimum of £30,000 being raised by the industry, with up to a further £12,000 a year on the basis of £80 for every further £100 of membership income. In his report, the director again refers to the studies of the effect of *p*H on the coagulation of dilute colloidal dispersions of clay minerals, which have indicated that except for the bentonites, which can be coagulated with low doses of aluminium sulphate at all *p*H values below 7·5, the amount of aluminium sulphate required to effect coagulation is at a minimum about *p*H 6·8–7·5. Work on the isolation of suspended colloidal matter in rivers using a continuously operated centrifuge is virtually complete, and a comprehensive investigation has been commenced on the effect of various factors in the preparation of activated silica. Other work has included the effect of physical variants on coagulation, the absorptiometric determination of aluminium, the leaching of lead stabilizers from polyvinyl chloride pipes and the determination of the permeability of plastic pipes to coal gas.

Museum of Applied Arts and Sciences, Sydney

IN common with most museums and art galleries the institution at Sydney is greatly in need of additional buildings to enable the Trustees to fulfil their obligations to the public. Lack of amenities for both visitors and staff, as well as inadequate facilities for exhibition, storage and preparatory work, was causing concern, and disappointment was expressed at the delay in implementing plans for improvement. Recently, however, some progress has been made and plans have been prepared for an extension to the present building and negotiations have started to take over an existing building on a neighbouring site for the storage and display of heavy machinery and transport exhibits. It is the aim of this Museum to show the latest trends in technology and thus provide inspiration and ideals for local manufacturers and others interested. To do so the staff must study developments in science at world research centres and by continuous contact endeavour to obtain specimens and relevant information regarding examples of applied science (Annual Report of the Trustees of the Museum of Applied Arts and Sciences, Sydney, for the year ended 31st December, 1958. Pp. 19. Sydney: Museum of Applied Arts and Sciences, 1960).

New Mineralogical Periodicals

THE formation last year of the Mineralogical Society of India has been quickly followed by the publication of *The Indian Mineralogist*, to be issued by the Society half-yearly as a medium for articles on crystallography, mineralogy, petrology, and allied subjects (Editorial Office: Department of Geology, A.C. College, Madras 25; price 10 R. per annum). The first number (Part 1, 1960) comprises twelve articles in 107 pages, most by Indian workers but a few contributed by Scandinavian and Australian mineralogists. If the initial standard is maintained, the journal will become one of international reputation and the Society should readily enlarge its present membership of 160, mainly resident in Southern India. Simultaneously, a new Russian journal has been issued by the East Siberian Division of the All-Union Mineralogical Society (*Zapiski Vostochno-Sibirskogo Otdeleniya Vsesoyuznogo Mineralogicheskogo Obshchestva*, Academy of Sciences, Moscow: Vol. 1, No. 1, 1959. Pp. 130. price 7r. 30k.), concerned principally with the topographical mineralogy of the territories east of the Urals. The eastward drift of Soviet geological–mineralogical interests is reflected also in the establishment this year of a new Geochemical Institute and Laboratory for Isotope Geology in the town of Irkutsk, administered by the Siberian Division of the Academy of Sciences, and one can expect that there will be no shortage of important contributions to the new periodical.

Compilation of Russian Journals

UNDER the title "Russian Journals", a union list of titles of 54 such periodicals held by four libraries in Manchester and Salford has been compiled for the benefit of scientists, research workers, students and librarians (pp. 14. Library Association: North Western Group. Reference, Special and Information Section. Manchester: Central Library, 1960). In an introduction, Mr. L. L. Ardern, under whose direction the list has been compiled, indicates that the Secretary of the Group will be glad to have details of other Russian titles held by other libraries in the area and to add these to a union list on cards held by the Regional Library Bureau. The entries are listed in alphabetical order of the Russian title, under the society's name if the periodical is published by a society. There is a full index under translitorated and translated titles. The participating libraries are those of the Manchester College of Science and Technology, University of Manchester, Royal Technical College, Salford, and Manchester Public Libraries.

Chromosome Abnormalities in Man

IN a recent issue of *Science Progress* (48, No. 190, April 1960) Dr. C. O. Carter points out that the year 1959 will be remembered for an important breakthrough in the science of human genetics. This was the discovery that certain congenital abnormalities in man are due not to 'point mutations', that is mutations involving only a tiny fragment of a chromosome, but to the addition or loss of whole chromosomes. Most mutations in animals and plants are 'point' mutations, and no change is apparent on examining chromosomes. Some mutations, however, are accompanied by visible changes in the chromosome. These vary from the addition or loss of whole chromosomes to the addition or loss of a small fraction of a chromosome. Investigation has shown that loss of an appreciable fragment, say, a fifth, of an average-sized chromosome is not compatible with life. The presence of extra fragments of chromosome, however, is better tolerated, though resulting in some degree of abnormal development, and in plants a number of examples of individuals with one extra chromosome have been studied. These 'trisomics' have the chromosome number $2n + 1$, and one chromosome is present in triplicate, not paired.

Resistance to Root-knot Nematodes

The immunity or resistance which some plants possess to attack by root-knot eelworms (*Meloidogyne* spp.) has led to the suggestion that the use of such plants in the rotation, or as trap crops, would effect a measure of control in root-knot infected land. A list of published records of plants showing complete or partial resistance to identified *Meloidogyne* species has recently been compiled and catalogued by Mary T. Franklin and D. J. Hooper on behalf of the Commonwealth Agricultural Bureaux (Plants Recorded as Resistant to Root-Knot Nematodes (*Meloidogyne* spp.). Pp. iii+33. Farnham Royal: Commonwealth Agricultural Bureaux, 1959. 7*s*. 6*d*.). In the first section the resistant plants are listed alphabetically, with the authorities for their scientific names as given in *Index Kewensis* and the breeding line, strain or varietal name if stated, followed by the species of *Meloidogyne* to which they are resistant, with the author and date of record. In the second section the plant species are arranged in their families and listed under each nematode to which they have been recorded as resistant. The third section gives the literature from which the records have been taken. It is emphasized that the plants listed are not necessarily representative of the whole plant kingdom. They are either crop plants in which resistance has been noticed by chance, plants that have been tested for resistance because they would be suitable rotation or cover-crops in root-knot infested areas, weeds growing among infested crops or plants bred for root-knot resistance. For the purpose of the compilation resistance is taken to be any relationship between plant and nematode in which the nematode fails to produce viable eggs. Records of partial resistance (defined as the condition in which the rate of reproduction of the nematode is extremely low in relation to the degree of soil infestation) have been included.

Cleaning Fossils by Ultrasonic Waves

An important article by Mr. J. N. M. Firth in the *Museums Journal* of April describes the cleaning of fossils in various types of matrix by ultrasonic waves. The instrument used was a 500-W. 'Soniclean' generator, type 1150, manufactured by Dawe Instruments, Ltd., and the cleaning tank of 1½ gallons was made of welded stainless steel. The specimen was either placed in a glass beaker containing cleaning fluid and floating in the tank or was suspended directly. A temperature of 65° C. was found to give the best results, and a few drops of liquid soap added to the fluid decreased the surface tension. It was also found advisable to replace the cleaning fluid when it became dirty, as such particles tended to damp out the waves. From a series of experiments, it would appear that there is a short interval of time at the start of treatment during which most of the dirt adhering to the specimen is removed. This is followed by a period of no further appreciable cleaning and finally by gradual degradation, the time for which depends on the lithological properties of the specimen.

Royal Geographical Society Research Fellowship

Dr. P. Salway, Research Fellow of Sidney Sussex College, Cambridge, has been awarded a Royal Geographical Society research fellowship for work on the geography and topography of the Roman Fenland. During past years the progressive desiccation of the Fenland has revealed an extensive system of Romano-British farms and settlements, with associated field-systems, droveways and watercourses, both artificial and natural. Continued desiccation will obliterate most of these before the end of the century. There is no part of the surface of Great Britain where the details of an ancient landscape can be so completely recovered as in the Fenland, and one product of Dr. Salway's research and field-work will be a detailed map of the region as it was in Roman times. The fellowship has been established by the Society with the aid of a grant from the Marc Fitch Fund.

Ciba Fellowships

The Ciba Fellowship Trust, which was founded for the purpose of furthering the exchange of ideas between scientists in the United Kingdom and on the Continent, has awarded the following fellowships for the academic year 1960–61: Dr. V. P. Arya (Banaras Hindu University, University of London and the Polytechnic, Zurich), to study in Stockholm (natural products chemistry); Dr. K. Jones (University of Sheffield), to study at the University of Heidelberg (organic chemistry); Dr. B. L. Mordike (University of Birmingham and University of Cambridge), to study at Göttingen (physical metallurgy); Mr. C. N. Banwell (University of Cambridge), to study at Zurich (spectroscopy); Miss P. M. Bryant (University of Oxford), to study at Basle (organic chemistry); Mr. R. Grinter (University of Exeter), to study at Zurich (physical organic chemistry); Mr. W. D. Hamilton (Queen's University of Belfast and University of Birmingham), to study in Yugoslavia (nuclear physics); and Mr. J. R. Miller (University of Cambridge), to study at Munich (inorganic chemistry).

National Science Foundation Awards

The National Science Foundation has announced the award of 1,200 graduate fellowships in the sciences, mathematics, and engineering for the academic year 1960–61. Successful candidates were selected from 4,696 applicants from all parts of the United States and its territories. Of the awards, 233 were made in the biological sciences, 946 in the physical sciences, including a number in interdisciplinary fields, and 21 awards were made in certain areas of the social sciences. The fellowships enable the holders to attend any appropriate non-profit-making institution in the United States or in a foreign country. The graduate fellowships provide basic stipends (for 12 months) of 1,800 dollars for the first-year level of graduate study, 2,000 dollars for intermediate years, and 2,200 dollars for the terminal year. These fellowships include additional allowances for dependants and tuition, as well as a limited travel allowance.

Royal Society of Arts: Industrial Arts Bursaries Competitions

The Royal Society of Arts has issued a report on the Society's annual Industrial Arts Bursaries Competition for 1959, in which 653 candidates from 81 schools and industrial establishments entered the 17 sections (pp. 56. London: Royal Society of Arts, 1960). A total of 34 bursaries amounting to £4,425 was awarded and the report includes the reports of the individual juries. Two inquiries were conducted by the Industrial Arts Bursaries Board in connexion with these competitions during the year. The replies to the first inquiry, which covered those

directly concerned with the competition, including the principals of some twenty of the larger schools, indicated that the overwhelming majority considered the competition was doing useful work and that the Society should continue to organize similar competitions. Many suggestions for the extension of the competition to cover a wider range of industrial and commercial needs were also received. The second inquiry was into the subsequent careers of winners of bursaries since 1946. Most of these young designers attribute their present employment, at least in part, to their success in these competitions, and all pay tribute to the opportunity which the bursaries provided, at the outset of their careers, to broaden their outlook and experience.

Nato Meeting on Ionospheric Research

GREEK national authorities have invited the Ionospheric Research Committee of the Nato Advisory Group for Aeronautical Research and Development to hold its next meeting in Athens during June 20–23. The four-day meeting will be devoted to discussions on radio-wave absorption. Among those who will be presenting papers are Mr. J. Ratcliffe (University of Cambridge); Mr. Finn Lied, director of the Norwegian Defence Research Establishment; M. Nicolet, director of the Centre National de Recherches de l'Espace (Belgium); and Prof. Vassy (Université de Paris). Further information can be obtained from the Advisory Group for Aeronautical Research and Development, Organization du Traité de l'Atlantique, Palais de Chaillot, Paris, 16.

Summer Courses in Western Europe

Two publications have recently become available concerning summer courses in Western Europe. "Residential Short Courses" is a six-monthly calendar issued by the National Institute of Adult Education and covers short courses to be held, during the summer, in Britain. "European Calendar of Short Summer Courses" covers a similar field of courses to be held in Western Europe as a whole, and is issued by the Bureau Européen de l'Education Populaire (Notes et Etudes, No. 15). Both publications are available from the National Institute of Adult Education, 35 Queen Anne Street, London, W.1, price 1*s.* each (postage 6*d.*).

Announcements

PROF. R. L. WAIN, professor of physical sciences in Wye College (University of London), has been awarded the Research Medal of the Royal Agricultural Society of England.

DR. C. J. T. CRONSHAW has been awarded the Hinchley Medal of the British Association of Chemists for his great services to the chemical industry while head of the Dyestuffs Division of Imperial Chemical Industries, Ltd.

MR. LESLIE T. MORTON, librarian of the National Institute of Medical Research, Mill Hill, London, N.W.7, has been given the Marcia C. Noyes Award of the Medical Library Association of America for his outstanding services to medical bibliography and librarianship. This Award has hitherto only been made to medical librarians in the United States.

HONORARY fellowships of the Royal Aeronautical Society have been conferred on Prof. W. J. Duncan, professor of aeronautics and fluid mechanics at the University of Glasgow and chairman of the Aeronautical Research Council; and Sir George Edwards, managing director of Vickers-Armstrongs (Aircraft) Ltd., and a past president of the Society.

DR. W. J. KROLL of Corvallis, Oregon, has been appointed the sixth Castner Memorial lecturer and will deliver his lecture, entitled "The Fusion Electrolysis of Titanium", in Glasgow on October 7. Further information can be obtained from the Society of Chemical Industry, 14 Belgrave Square, London, S.W.1.

THE German Academies and the Austrian Academy of Science have announced that an edition of the letters of Alexander von Humboldt (1769–1859), the German naturalist and traveller, is in the course of preparation. Owners of any letters by Humboldt or addressed to him are invited to communicate direct with Prof. Dr. H. Ertel, chairman of the Alexander von Humboldt-Commission, Deutsche Akademie der Wissenschaften zu Berlin, Berlin 6, Germany.

THE fourth volume of the *Journal of Electronics and Control* contains interesting papers on plasma physics and on recent developments in the theory of transistors. A particularly interesting research note describes a switching diode, using gallium arsenide, in which hole storage effects have been so reduced that transition is less than two milli-micro-seconds.

A SYMPOSIUM on recent developments in the applications of nuclear science for peaceful purposes will be held in Hauradan, Iran, during July 6–19. Further information can be obtained from Dr. M. L. Smith, CENTO Institute of Nuclear Science, P.O. Box 1828, Tehran, Iran.

THE annual Electronics and Instruments Exhibition and Convention of the Institution of Electronics is to be held, at the Manchester College of Science and Technology, during July 7–13. Further information can be obtained from W. Birtwistle, general secretary of the Institution of Electronics, 78 Shaw Road, Rochdale, Lancs.

A JOINT meeting of the Challenger Society and representatives from the Marine Laboratories (Development Commissioners Scheme) will be held in the Department of Zoology, University of Cambridge, during June 23–24. Further information can be obtained from Dr. R. Bainbridge, Department of Zoology, Downing Street, Cambridge.

THE Nutrition Society is holding a symposium at Rothamsted Experimental Station, Harpenden, on "Food Losses in Field and Store", on July 2. Further information can be obtained from the honorary programmes secretary of the Nutrition Society, Miss D. F. Hollingsworth, at the Ministry of Agriculture, Fisheries and Food, Great Westminster House, Horseferry Road, London, S.W.1.

An international conference, the first of its kind, is to be held on "Congenital Malformations" by the International Medical Congress, Ltd., at Church House, Dean's Yard, Westminster, London, S.W.1, during July 18–22. Further information can be obtained from the Secretariat of the First International Conference on Congenital Malformations, 67 New Bond Street, London, W.1.

ERRATUM. In the note entitled *Instrument Abstracts* in *Nature* of April 30, p. 359, it is stated that the issue dated January 1960 is No. 1, Vol. 1; this is incorrect. It should read: No. 1, Vol. 15.

U.S. NATIONAL ACADEMY OF SCIENCES

MEDALS AND AWARDS

THE following awards by the U.S. National Academy of Sciences have been announced: The James Craig Watson Medal, to Prof. Yusuke Hagihara, formerly professor of astronomy in the University of Tokyo and director of the Tokyo Astronomical Observatory and later professor in Tohoku University, a post from which he has just retired. Prof. Hagihara is best known for his original contributions to the field of celestial mechanics, the study of celestial bodies in motion. Perhaps his most significant work has been his paradigms for the general problem of the stability of motion—a basic question in celestial mechanics. Prof. Hagihara's mathematical talents have also been turned to one of astronomy's most vexing puzzles —the restricted problem of three bodies. Astronomers have long sought, without complete success, to calculate the relative motions of three bodies when given the positions and motions of the bodies at a point in time. Celestial mechanics is not the only astronomical field of interest in which Prof. Hagihara has gained distinction. He has also made original contributions to theoretical astrophysics, the theory of relativity, and solar eclipses. A prodigious scientific author, he has published more than twenty-five papers and monographs on celestial mechanics alone, and is the author of ten books on various astronomical subjects.

The Agassiz Medal, in recognition of original contributions to the field of oceanography, to Dr. Anton Frederick Bruun, of the University of Copenhagen. Dr. Bruun is a leading authority on life in the deep sea, and has won similar distinction as an effective leader of oceanographic expeditions. In addition to the many expeditions in which he has participated, Dr. Bruun led an expedition during 1945–46 to tropical West African waters, and, during 1950–52, headed the *Galathea* expedition that circled the globe in a study of the ocean deeps. At present, he is directing an expedition to the South China Sea, sponsored jointly by the Scripps Institution of Oceanography and the International Co-operation Administration. It was the *Galathea* expedition that earned Dr. Bruun especial acclaim for his ability to enlist scientists from many nations in a co-operative research programme. Although a voluminous series of reports has already resulted from the *Galathea* findings, it is anticipated that additional reports will be published for many years to come. One of the expedition's most significant achievements was its trawling of the approximately 34,500-ft. deep Philippine Trench, just east of the Islands. Most dramatic finding of the *Galathea* expedition was the discovery of a 'living fossil', the mollusc *Neopilina*, the nearest relatives of which were thought to have become extinct some three hundred million years ago (*Nature*, **179**, 413; 1957). During 1926–33, Dr. Bruun was engaged in oceanographical research as a member of the Danish Fisheries Commission. In 1933 he was appointed curator of molluscs in the Zoological Museum of the University of Copenhagen. He has also held appointments at the Carlsberg Laboratory, the Marine Biological Laboratory, and the Danish Aquarium.

The Kimber Genetics Award, to Prof. George Wells Beadle, professor of biology and chairman of the division of biology at the California Institute of Technology. Prof. Beadle's specific research interests have been, successively, the genetics and cytology of maize; the genetics of *Drosophila melanogaster*; the chemistry and the biology of eye pigment in *Drosophila*; and the chemical genetics of *Neurospora crassa*, or red bread mould. Perhaps the most significant result of his work has been the finding of new ways to trace the action of genes. The best-known of these techniques is the use of *Neurospora* to follow the steps by which genes influence the synthesis of vitamins, amino-acids, and other basic ingredients of life. This simple and ingenious tool was developed by Dr. Beadle in collaboration with Dr. Edward L. Tatum and others. Prof. Beadle has occupied his present chair at the California Institute of Technology since 1946. Previously, he was professor of biology at Stanford University during 1937–46, and assistant professor of genetics at Harvard University during 1936–37. Prof. Beadle has been elected a foreign member of the Royal Society of London this year.

The J. Lawrence Smith Medal, for outstanding investigations of meteoric bodies, has been awarded to Dr. E. J. Öpik (*Nature*, April 23, p. 280).

The Public Welfare Medal of the National Academy of Sciences has been awarded for "eminence in the application of science to the public welfare" to Dr. Alan T. Waterman, director of the National Science Foundation. Established in 1913 by Mrs. Helen Hartley Jenkins in honour of her father, Marcellus Hartley, the Public Welfare Medal is considered to be the most distinguished of the Academy's medals. It is unique among them in that it is awarded for outstanding public service in the uses of science, rather than for achievements within a particular scientific discipline.

SIXTH-FORM SCIENCE AS A PREPARATION FOR UNIVERSITY WORK

IN March 1958 the Senate and Council of the University of Birmingham approved a proposal for an inquiry to be held into the suitability of the General Certificate of Education (Advanced Level) syllabuses in science as a preparation for direct entry into first-degree courses in the Faculty of Science. This useful report, now published, was financed by the Gulbenkian Trustees. The subjects under consideration were biology, chemistry, geography and geology, mathematics and physics. The Panel began its work by considering what sixth-form training would be most valuable to a pupil who

proposed to enter a first-degree course in a biological subject*.

It was felt to be essential, in view of the increasing emphasis on the experimental aspects of biology, that such pupils should acquire an understanding of the basic sciences—chemistry, mathematics and physics. They should preferably study biology, but the Panel would not exclude from a university course those whose only background was a sixth-form knowledge of the three other subjects. "Intending biology students should be taught to practise the scientific discipline of observation and deduction, and to despise that pointless accumulation of facts and terms which sometimes passes for scientific education and they should be given training in clear, purposeful and accurate descriptive writing in their own language". The Panel was impelled by two main considerations to pronounce against botany and zoology and the current biology, and in favour of a single, revised course in biology, which should stress the underlying principles of the subject and show the fundamental similarities of living things as well as the fundamental differences between plant and animal.

The present chaotic system of examinations at Ordinary, Advanced and Scholarship levels, with different requirements from each Board, is critically considered, and so useful proposals are made towards a more rational system. The approach of the teacher to the syllabus is largely determined by the type of examination paper which is set. Although the marking of a large number of scripts by many examiners is not easy, and this has led to the use of questions which can be marked quickly and precisely, these questions may not be of the type best suited to selecting the best candidates.

At present, selection for entry to university is made on the basis of Advanced-level performance, supplemented by an interview. The latter occasionally reveals that a student with good marks depends on a particularly good memory and that this kind of entrant usually fails to maintain his performance in the university. It was felt that the introduction of Scholarship-type questions would enable a distinction to be made between the fundamentally sound pupil and the 'memory-man'. In general, there is a remarkable parallelism between the weaknesses, difficulties and suggested remedies in all the subjects. Very useful suggestions are made towards the teaching of fundamental principles, and the eschewing of the unintelligent learning of masses of factual snippets. The report of the Panel is so detailed and yet succinct that further summary is not possible.

This report throws into relief the need for other investigations. Each university can have its own pre-requisites for entry to its courses, and, in this matter, there are differences in standard and scope between science subjects. This makes difficulties for the sixth-former who, in the hope of securing entrance to a university, applies to a number of them. While it is impossible, and if it were possible it would be undesirable, to secure uniformity in this matter, much wastage of effort (even clerical effort), confusion and disappointment result.

It is hoped that other universities will issue similar reports, for the matter is both socially important and urgent. Although it is outside the terms of reference of the present report, there is a more general problem of a parallel nature which is receiving some attention in an inquiry of which the results are awaited. Too many sixth-form students, who seem to promise much, fail to do well at the university. This is a source of disillusion, a wastage of brain-power and money, and a failure to meet social needs, which needs careful investigation and, if possible, a remedy.

There are other matters which should be considered, though these are outside the scope of the present report. For example, there is the failure of the less-than-brilliant sixth-form student to adjust himself quickly enough when he comes to the university with its short terms and social temptations presented by the Students' Union, the failures to use the vacations adequately and the early dates of the examinations in the last undergraduate year. The shortages of good sixth-form teachers, particularly of science and mathematics, and even of good examiners are other, but nevertheless important, matters.

W. L. Sumner

* University of Birmingham. Report of an Enquiry into the Suitability of the General Certificate of Education Advanced Level Syllabuses in Science as a Preparation for Direct Entry into First Degree Courses in the Faculty of Science. Pp. v+212. (Birmingham: The University, 1959.)

THE NEEDS OF UNIVERSITY STUDENTS

In a memorandum submitted to the University Grants Committee, the National Union of Students describes its attitudes to the problems involved in university expansion. Because of their direct experience, the views of the National Union of Students are likely to be of greatest significance where it discusses the needs of students. It has recently suggested, for example, that if adequate and suitable accommodation, which may be of many different kinds, cannot be provided near at hand for the whole student population, then neither the expansion of an existing university nor the establishment of a new one should be allowed (Memorandum to the University Grants Committee on the Expansion of University Education, 1960–1970. Pp. 12. London: National Union of Students of England, Wales, and Northern Ireland, 1960). Insufficient attention has been paid to this problem in the past, with consequent harmful effects on the undergraduate, as a person and as a student, and upon the community of which he is a member.

While there is a variety of different types of accommodation which fulfil the needs of students, great benefit is derived from time spent in residence. Ideally, halls of residence should be composed of comparatively small units of ten to fifteen rooms, each providing a small kitchen and a discussion room. The units are often well arranged on staircases with small groups of rooms on each floor. There might be three such units on each of three or four sides of a small court, so that each block provided accommodation for some 150 students. There is, however, a considerable range of ways in which good residential accommodation can be provided; the student flats at King's College, Newcastle, and the Studentenhaus at West Berlin University are examples of such

variations. There is considerable scope for experiment in this field.

When planning residential accommodation, the architect should consult fully with the university authorities and with student representatives to ensure that the most economic as well as the most effective lay-out is obtained, encouraging the corporate spirit of the university as well as facilities for private study and relaxation of the individual student.

Since the provision of enough residential places is economically unattainable in the near future, the Union emphasizes that not all forms of lodging are necessarily suitable for students, who need a quiet room for study, flexible hours and a sympathetic atmosphere. Lodgings that may suit some purposes can be quite unfitted for study. In a small town such as Aberystwyth, where the university dominates the life of the community, students often find that landladies come to understand their needs and take a real interest in providing the right environment for study. If the university atmosphere and community is to develop, all accommodation should be in close proximity to the university centre.

Another important factor is the academic and administrative structure of the university. Apart from the fact that this can determine the success or failure of its development as a community, it will have repercussions on the breaking down of faculty or departmental inter-relationships, which is already taking place through increased specialization ; it will also affect the balance of Faculties and of undergraduate/postgraduate ratios. The structure most conducive to a fully integrated university education is the collegiate structure as will be developed at Bristol. In the expansion of existing universities it may well be desirable to avoid the piecemeal addition of extra sections to the present structure, but rather to change to the collegiate pattern.

All the major buildings of the university—halls, union building, laboratories, libraries, lecture theatres and refectories should be grouped together on one site. It would be valuable if a few small buildings in the various towns selected as new university sites could be leased to the university for use as, say, libraries for the smaller Faculties, and as staff houses where some tutorials could be given ; arrangements might also be made for the designation of a university church within the town. Such facilities should not be allowed to detract from the creation of a single university unit.

There should be some degree of specialization in each university in selected areas of study. Such specialization could build up a reputation, encourage research, simplify application problems, attract interested staff, and might also prevent duplication of capital costs on research equipment. Development should be considered in relation to the paramount need to operate a proper tutorial system.

The major need of students is adequate provision for the development of an active student community. There should be a Students' Union building, providing a meeting place and a centre of student life, which should, where possible, be a separate building.

Where new laboratories are being erected, these should be designed in conformity with good safety regulations. It is also hoped that the need for an adequate and well-equipped clinic is generally recognized. These are already provided in many universities, and will be essential in new universities where the treatment of physical or mental illness should not be left to the care of local doctors who might not be readily accessible.

SENSORY SPECIALIZATION IN RESPONSE TO ENVIRONMENTAL DEMANDS

THE third of a series of Zoological Society of London symposia was held on March 4 under the title "Sensory Specialization in Response to Environmental Demands". It was organized by Prof. O. Lowenstein, and the meeting was held under the chairmanship of Prof. R. J. Pumphrey.

In his introductory remarks, Prof. Lowenstein directed attention to the somewhat Lamarckian ring of the title ; but he envisaged that none of the topics under discussion would make it necessary or desirable to infringe neo-Darwinian orthodoxy. Outlining the rationale of the programme, he went on to point out that two different types of adaptive specialization could usefully be surveyed in this context. The first may affect the whole range of sensory modalities as a means of adapting an animal to a successful integration into a sub-social or social organization. This type is found, for example, in locusts and to a more extreme degree in the social Hymenoptera. The second type of sensory specialization may be confined to one sense organ only, the eye in nocturnal, deep sea, or cave animals, or the ear in animals like bats and cetaceans which find their way about by means of sonar.

A comparative analysis of sensitivity limits may also reveal instances of adaptation to special environmental circumstances. The sensitivity limits of photo-receptors may serve to illustrate this point.

In a paper on the sensory equipment of the migratory locust, Dr. P. T. Haskell (Anti-Locust Research Centre, London) showed that special sensory adaptations are related to the control of steady and stable flight of the swarming insect and to the maintenance of cohesion between locusts in the swarm. 'Dorsal-light' reaction of the compound eye and proprioceptive feed-back from receptors on the cervical hair plates control anti-roll stabilization, whereas anti-yawing responses are elicited by cephalic hair sensilla. Preferred inter-locust distance in the swarm is maintained by an equilibrium between visual attraction and repulsion in response to auditory and other mechanical stimuli.

Fully social organization as shown by the social Hymenoptera involves a number of instances of extreme sensory specialization in the various castes of ants and bees. Dr. H. Kalmus (Galton Laboratory, University College, London) described some new results concerning colour vision and odour discrimination in the honey bee. Whereas scent is an important item of information in bee-to-bee communication, symbols for colour are very likely missing from the 'vocabulary' of the social insects. A discussion of the mechanism of analysis of the plane of polarized light was illustrated by an electron-micrograph of an insect ommatidium. Dr. Kalmus suggested that the chief sensory adapta-

tion in the social Hymenoptera consists of a co-adaptation of pre-existing sensory mechanisms with patterns of motor activity into systems of communication.

In a paper on the sensitivity limits of photoreceptors, Dr. F. H. C. Marriott (Department of Physiology, Oxford) stressed the necessity of presenting measurements of spectral and absolute threshold sensitivity in such a form that they can be compared throughout the animal kingdom. Such measurements made on five species, namely, man, cat, owl, the amphibian *Xenopus*, and the flatworm *Dendrocoelum*, were discussed and compared with special reference to the differences in the visual sensory structures.

Dealing with the problems of the sensory aspects of adaptation in cave animals, Dr. G. Thines (Laboratory of Experimental Psychology, University of Louvain) gave a paper on sensory degeneration and survival in cave fishes. After a critical discussion of the general idea of evolutionary 'progress', Dr. Thines defined regressive changes as a gradual reduction of independence leading to the 'abnormal' character of regressive faunas such as cave fishes. The survival value of regressive changes in photoreceptors in cave fishes was then assessed and this led to the introduction of the hypotheses of 'remanence' and 'vicariance' with regard to the significance of the continuation in eyeless cave fishes of the pre-existing epigean photokinetic functions and of the supplanting of the functionally insufficient eye by the pineal organ. Dr. Thines then showed a short film on the blind fishes of Somaliland.

The design of fish and cephalopod eyes in relation to their environment was discussed by Dr. E. J. Denton (Marine Biological Laboratory, Plymouth). The density, the refractive medium, absorption and scattering of light by the medium all have their effect on the morphology and functional characteristics of the eyes of marine animals. At greater depth and at night the light emitted by luminescent animals may be more important than the light coming from the sky. Light will only be 'useful' for vision if it can be absorbed by photosensitive pigments. Pigments then play an important part in the adaptive specialization of eyes. The elongation of the rods of the deep-sea fish retina, although raising sensitivity, could have an adverse effect on visual acuity were it not for the existence in these elongated rods of marked channelling of light along the rod. Pigment migration between rods also diminishes the blurring effect of lateral spread of light.

The symposium ended with an account by Prof. F. P. Möhres (Department of Comparative Physiology, University of Tübingen) on sonic orientation of bats and other animals. Prof. Möhres recounted how, during the Second World War, Spallanzani's classical observation of orientation of bats in the dark found its explanation in the simultaneous discovery of ultrasonic echo-location in the vespertilionid bats by Griffin, Pierce and Galambos in the United States, by Dijkgraaf in Holland and by himself in Germany, all of them confirming a hypothesis advanced by Hartridge in 1922. In vespertilionid bats short volleys of ultrasonic pulses of a broad and irregular frequency spectrum are utilized in a system of time difference estimation in which the time difference between the emitted signal and its returning echo is a measure of the distance of the reflecting object, and the time difference between the arrival of the echo at the two ears serves as a measure of direction. A completely different sonar mechanism of orientation was, however, discovered by Prof. Möhres to exist in the horse-shoe bats (Rhinolophids). While flying, the horse-shoe bats keep their mouths closed and the horse-shoe points in the direction of flight, or in stationary animals into the direction of 'interest'. Ultrasonic sound, consisting of prolonged cries without frequency or amplitude modulation, is emitted through the nostrils and cast about in a beam 'focused' by the horse-shoe. In Rhinolophids the essential feature of ultrasonic orientation is thus, according to Prof. Möhres, not a time difference but an intensity-difference estimation. The animals are thus believed to assess the sound intensity of their orientation cries reflected by objects in their environment in turning their ears point to point through the range of space under scrutiny. Rendering the ears immobile abolishes successful orientation. It must be mentioned here, however, that certain aspects of the *modus operandi* of sonar as summarized by Prof. Möhres are meeting with adverse criticism from a number of quarters.

Finally, Prof. Möhres described how a search for mechanisms intermediate between the vespertilionid and the rhinolophid extremes led to the discovery of intermediate situations in the Hipposideridae and the Megachiroptera (fruit bats). However, no conclusive phylogenetic picture emerged, and the origin and ways of the evolutionary lines remain hidden in the darkness of the past.

O. LOWENSTEIN

ASPECTS OF OROGENS

THE Geologische Vereinigung held its fiftieth anniversary meeting under the presidency of Prof. G. Fischer in Würzburg during March 12–14. The theme for discussion was the Orogen, the mobile belts or those parts of the Earth's crust in which mountain chains are formed. The process of orogeny can best be considered in respect of time; a time when the materials accumulate and become compacted to form the building materials for the mountains; a time when these rocks are disturbed by forces usually regarded as being produced by shrinking of the Earth's surface; and a time when magmas from deeper horizons within or below the crust break through and pierce the strata whether quiet or crumpled and broken. Part of the magmatic activity consists of the release and movement of reagents which metamorphose the sediments. Then comes a final act in which vertical movements are considerable, helping to account for the present stature of the mountains and their wild or orderly scenery by exposing the various structures to erosion.

There is also a space relationship. The orogens are restricted to comparatively narrow belts in which mountain building takes place. The arrangement of the mountains within these belts is not simple or regular. One reason for this is that earlier chains may have stood along or across the line followed later by younger mountains, and their presence, or that of

broken fragments of these old ranges, interferes with the growth and orientation of the later ones. The structures themselves may be divided into those formed under comparatively little cover and therefore at low pressure, and others which have formed deep in the crust under high pressure. The former are more often well exposed in present-day mountains, but the latter are seen only where erosion has been unusually deep. The former have often escaped intrusion, but the latter have suffered magmatic injections and are in part complicated by metamorphism.

The forces at work within the orogen also vary. Opinions diverge as to what initiates the commencement of growth, and it is probable that tension played a part. Lateral compression undoubtedly was important during much of its life and resulted in the formation of the folds and associated thrust-faulted structures. At a late stage, however, tension again developed and allowed normal faults to form accompanied by floods of lava or the great sheets of tuff or volcanic ashes.

Most of the papers delivered during the meeting by some 35 speakers were orthodox enough, but one by Dr. L. Egyed (Budapest) seemed more than a little heretical to some in the audience. He suggested that below the layers of ultrabasic rocks reputed to underlie the sima, there exists less-basic material; magma containing water and other light fugitive constituents which are absent from peridotites. Such ideas appear to be in accord with Dr. Egyed's published views that the Earth is an expanding body, not the contracting one, described, for example, by the late G. M. Lees, which is how many other geologists would have it.

In the opening paper Dr. R. Trumpy (Zurich) remarked that no scheme of mountain building as yet worked out can be applied generally. Each orogen has to be treated as an individual. As well as the disturbing influence exerted by fragments of earlier mountain-chains the type of sediments involved played an important part in determining the shape of the resulting structures. For example, the thick column made up of alternating thin beds of muds and sands, characteristic of eugeosynclines, fold in a totally different style from that found where the strata are mainly thick bodies of limestone and sandstone such as accumulate in miogeosynclines. Examples to illustrate his opinions were chosen from the western Alps which, although well known, are complicated and are by no means typical of structures in some other orogens. Dr. E. K. Walton (Edinburgh) described the eugeosynclinal region of the Scottish Southern Uplands where the Ordovician and Silurian strata are now regarded as being thicker than was previously estimated and as including higher stages in the Silurian than those hitherto recognized there. Broader asymmetrical folds with steep thick flanks and disturbed by large strike faults are commoner structures than the groups of innumerable isoclinal folds depicted in the classical sections by Peach and Horne.

The spilites of the Lahn–Dill region discussed by Dr. H. Hentschel (Wiesbaden) contain albite, chlorite, quartz and calcite instead of the normal minerals of a basaltic suite, plagioclase, pyroxene and olivine. The possibility that sea water entangled among the geosynclinal sediments reacted with basaltic intrusions is considered as probable.

The veteran Dr. P. Eskola (Helsinki) referred to juvenile granites produced by intrusive magmas formed from components from within the Earth which have diffused outwards. These he contrasted with secondary granites derived from re-working of metasomatized sediments or migmatites. These may appear as disharmonic stocks even in epeirogenic regions. The presence of an aureole of contact metamorphism serves to demonstrate cases in which a hotter intrusion pierced a colder environment.

Because the bodies of sial and sima extend laterally as sheets which are nearly horizontal it is easier to imagine the movement of material along rather than across them, but where they are in an unusual relationship, such as occurs near the edge of an orogen where it touches the margin of an ocean basin, transverse movement of magma should be easier. Dr. P. Michot (Liège) directed attention to the importance of such marginal intrusions and suggested that they may originate at depth in the katazone. Now that methods have been devised enabling rapid analyses to be made, Dr. K. R. Mehnert (Berlin) considered that a new and important research tool is available which may be applied to the study of the distribution of alkalis throughout the body of an orogen. Dr. H. Borchert (Clausthal) also spoke of geochemistry, referring to the association of the copper, zinc, lead and barium ores on one hand and chromium, nickel and titanium ores on the other.

The complicated structures of the Central Pyrenees, involving the interpretation of areas with slaty cleavage and of orientation patterns assumed by newly formed metamorphic minerals, were described by Dr. H. J. Zwart (Leyden). Dr. E. Bederke (Göttingen) considered the relationship between stress and regional metamorphic effects. He cited examples from the Sudeten hills and western Alps in which active phases of disturbance were separated by long intervals of quiet. The late history of the orogen was the theme of Dr. A. J. Pannekoek's (Leyden) discourse. Folding, faulting and differential vertical movements contribute to the present morphology. Theories of mountain building should be capable of explaining the late movements as well as other early ones. The association between late movements and post-orogenic vulcanism suggests the intervention of a magmatic process. The breaking down of a basin like the Mediterranean with excess gravity may be connected with the uplift of neighbouring hills and be independent of the structure of the orogen.

Dr. A. Winkler von Hermaden (Graz) described examples of structures from the western Alps and Croatia, while others chose examples from central Asia, central Africa, the Carpathians, the Balkans, the east Alpine zone and the Ligurian Alps with part of the neighbouring northern Apennines. The object of four other papers was to make use of features seen in Central and South America to show that structures there run nearly parallel to the present coast; that there has been deposition and folding along an old mass lying to the east; that breaking down accompanied by intense vulcanism and intrusion has produced a graben-like feature a little inland from the coast; and that large uplifts have taken place rather recently. The frequent earthquakes both out at sea and up to 100 miles inland are taken to indicate that the region is still tectonically active.

During the session the Steinmann Medal was awarded to Prof. H. H. Read. The text of the contributions made by the several speakers is expected to appear in the next volume of the *Geologische Rundshau*.

J. V. Harrison

INDIAN INSTITUTE OF SCIENCE, BANGALORE

GOLDEN JUBILEE SYMPOSIA

As a part of scientific activities during the Golden Jubilee Year (1959–60) of the Indian Institute of Science, Bangalore, which was inaugurated in February 1959, the Department of Chemical Technology and Chemical Engineering arranged symposia on "Hydrocarbon Synthesis and Hydrocarbon Conversion" and on "Mass Transfer" during January 11–13, 1960. The technical session commenced with an address by Prof. W. Groth, director of the Physical Chemistry Research Institute, University of Bonn, who discussed new developments in the field of emission mass spectroscopy. A number of original papers covering different aspects of the two subjects of the symposia were also read and discussed. Papers were presented by scientists from the United States, the United Kingdom, Germany and Italy, as well as from many Indian universities and institutions.

In the session on hydrocarbon synthesis a paper on the "Performance of Iron Catalysts and the Promoter Action of Alumina and Platinized Asbestos at Atmospheric Pressure" was presented in which the authors indicated that alumina behaved as a structural promoter and increased the polymerization activity and hydrocracking, whereas platinized asbestos improved the overall activity and hydrogen consumption, keeping the formation of gaseous hydrocarbons low. Papers on "Fischer–Tropsch Synthesis in Fluidized Bed" using an Fe–Cu–MgO–K_2O catalyst and the "Rheinpreussen–Koppers Liquid-phase Process" were also read. In the former method the performance compared favourably with the already established units. In the latter process the authors reported considerable selectivity for C_3 hydrocarbons and versatility to suit the market requirements. A probable mechanism of Fischer–Tropsch synthesis based on intermediate reactions of the carbonyl and oxo-complex types was reported and discussed. The possibility of producing gas from methane-rich low-temperature carbonization gas using a nickel catalyst with a high conversion (92 per cent) at a temperature of 900° C. was reported. The paper on "Rectisol Process for Gas Ultra-purification under Elevated Pressure" indicated the advantage of simplicity of operation in a single unit.

Concerning hydrocarbon conversion, reformation by hydrogenation, cracking, etc., a number of interesting papers were presented. The medium pressure hydrogenation of coal-tar distillate with a desulphurization catalyst was reported to have resulted in the formation of a refined product which could be used as a starting material for the chemical industry or as motor fuel. The results of cracking of high boiling fractions from Nahorkatiya crude oil over a silica–alumina catalyst showed yields of high percentage of middle distillates. The use of the same catalyst promoted by calcium oxide for the production of lubricating and diesel oils from paraffin wax from Assam crude oil was also reported. The gasification of hydrocarbon oils for conversion into gases of high B.T.U. by cracking over various contact beds, including activated coke and in an atmosphere of carbon dioxide, indicated the possibility of developing a single-stage continuous process for preparing gas of uniform composition and for meeting standard requirements. One paper dealt with the structural features of reactants on the basis of which predictions could be made regarding the reactivity and nature of products obtainable in the alkylation of olefins with paraffins and alkylbenzenes under pressure. There were three papers dealing with oxo-reactions. In one paper, the author reported the synthesis of propionaldehyde, propionic acid and methyl and ethyl propionate by the oxonation of ethylene. The other two papers dealt with the thermodynamics of oxonation of butenes, preferential oxonation, etc.

In the session on mass transfer a number of interesting papers were presented, some of them dealing with isotope separation. The separation processes based on ion-exchange methods with special reference to band displacement and elution principles, including elution chromatography, were reviewed and their application to separation of low- and high-mass numbers up to calcium was discussed. The processes for production of carbon-13, nitrogen-15 and oxygen-18 were also surveyed. The derivation of a relationship for the calculation of transfer columns for heavy-water enrichment plants, and the comparison of the theoretical and experimental values obtained in case of Bitterns water were discussed. A simplified and experimental modification of the temperature-float method, as developed recently, was described and discussed with reference to such factors as float design, horizontal and vertical temperature gradients in the float chamber, etc., for isotopic analysis of heavy water. Based on experimental data, the possibility of co-current distillation in a gas stream for the enrichment of heavy water was indicated. The theory of separation potential of thermally controlled gas centrifuges, and some experimental results obtained from centrifuge models *ZG*3 and *ZG*5 for separation of argon, xenon and krypton isotopes were presented.

A method of determining the mass transfer rates by means of a single particle placed in a bed of similar-sized inert particles by radioactive tracer technique and the application of the same in the case of ion-exchange processes was described. The results obtained in the steam-stripping of carbon dioxide from sodium carbonate–bicarbonate solution in perforated plate columns indicated that the liquid hold-up in the column is chiefly a function of the rate of flow of the liquid, which itself is dependent on the decomposition of the sodium bicarbonate during the process. The studies on the mechanism of mass transfer in naphthalene-packed beds indicated that the values of diffusivity coefficients differed from those obtained by other investigators. This was attributed to some other mechanism such as surface resistance, the diffusion of solute molecules, etc., besides the molecular diffusion in the surrounding gaseous film. A generalized correlation of operating hold-up in packed columns, which gave a value within 5 per cent of the observed values in most cases, was discussed. A method has been proposed for the design of a

fixed-bed catalytic reactor for vapour-phase reactions based on the reaction-rate constant and the overall heat-transfer coefficient, and on the assumption that there is no radial temperature variation. Dixon-ring packings prepared locally were reported to be highly efficient in laboratory fractionating columns. An empirical equation based on experimental results obtained with a Northrup and Anson diaphragm cell for calculating diffusivity coefficients of organic acids in ethanol–water mixtures was proposed.

A re-cycling pressure-equilibrium still was described in one paper, and the results obtained for benzene–toluene and ethanol–benzene systems up to 200 p.s.i.g. were discussed.

In one paper attempts were made to explain the heat-transfer characteristics of stirred and gas-fluidized beds of particles on the basis of a theoretical model in which the rate of heat transfer from a heated surface in contact with a stirred bed is dependent on the rate of replacement of particles at the surface by particles of 'average' temperature from the bulk of the bed. The experimental results obtained in an apparatus in which circulation of particles was caused by stirring were found to agree with the model proposed.

Some review papers dealing with the theory of air-drying of solids and its application for the design of industrial dryers, separation of hydrocarbons by chromatographic methods, the application of urea and thio-urea complex formation for separation in petroleum industry, the various petroleum-refining processes with special reference to coking, thermal cracking and catalytic cracking, and the recovery of catalytically cracked feed stocks from petroleum residue by propane-decarbonizing were also read.

R. L. Datta

PSYCHOLOGY OF GIFTED CHILDREN

HIGH intelligence is probably the most valuable of a community's social and economic assets. From gifted individuals come the sources of creativity, of leadership and of progress at all levels—moral, artistic, scientific and political. On the other hand, the highly intelligent maladjusted or anti-social individual can be a greater threat to his fellows and to his society than his less able contemporaries. Thus, the best all-round education and training of the most able group of children and adolescents are essential aspects of the conservation and exploitation of our natural resources. To some extent, the Education Act of 1944 recognized this, crowning nearly half a century of attempts to give able children the right to a fitting education in school, and later in university, irrespective of their social background.

Dr. W. D. Wall, director of the National Foundation for Educational Research in England and Wales, has now examined the knowledge available as a basis for reviewing that part of our educational system and methods which deal with the pool of high ability (*Educational Research*, **2**, No. 2; February 1960).

Genius in its fullest sense is of immense importance to any society. As, however, it is very rare, and in any event so little is known about the conditions which produce it, attention must be concentrated on the general pool of high intellectual ability from which will be recruited scientists, teachers, leaders in political and business life and the professions generally. At present in the English educational system it is assumed that this pool is defined by the ability to profit from a grammar school type of curriculum in adolescence. Few of the outstandingly able children now fail to qualify for entry to grammar school.

Our present allocation procedures, however, although generally more efficient than any other form of examination, can take no account of a number of factors which determine potential performance. Virtually a child's education during adolescence and consequently his chances of higher education are determined by the result of five years in the primary school.

Ability, however, as shown in school learning and afterwards by vocational success or social contribution, is only in part determined by strictly genetic factors. 'Operational intelligence' is an innate product of ability and the educational effects of the environment. The ability which psychologists see and attempt to measure in children and adolescents is the sum of inheritance, motivation and nurture. Marked lack of affectionate mothering will result in a lowering of ability, and emotional deprivation in infancy particularly affects the development of verbal concepts and abilities. If this continues beyond a certain point, its effects are irreversible. From the work of the Population Investigation Committee, which is following the growth of some 5,000 children born in 1946, it seems to be indicated that the quality and level of parents' interest in their children markedly affects not merely academic attainment but also the complex general ability measured by intelligence tests. There is, therefore, a proportion of children whose talents never show themselves to the full because the environment starves them in important ways.

General ability and talent well above the average may never declare themselves if nurture is lacking, or if emotional deprivation is marked.

It is difficult to over-estimate the importance of a constructive education at home, and in the school, for able children if they are to realize their intelligence capabilities to the full. However, socially and personally something more than a merely reasonable state of emotional equilibrium is necessary. It is of fundamental importance that highly intelligent children and adolescents should see their high endowment, not as a source of egocentric and purely personal advancement, but as a trust which increases their responsibilities towards others. It is doubtful whether the present stress on inter-personal competition which marks some facets of our educational system is fully desirable; and whether sufficient demands are made upon our ablest ten per cent of pupils.

The notion is still current that genius is maladjusted emotionally, often feeble physically, and that poets, in particular, tend to die young. Similarly, the popular picture of the highly intelligent child presents him as puny and bespectacled, as precocious in language interests as he is retarded in his emotional

development, liable to over-fatigue and difficult to get on with. There is little truth in these stereotypes. The able child tends to be superior to the average in every way: there is no law of compensation which offsets high intelligence by inferiorities in non-intellectual fields. The degree of superiority to the average is not the same in all fields and is greatest in those most closely related to intelligence, that is, originality, intellectual interests and achievement test results. Terman's extensive investigations showed that "contrary to the theory that great achievement is usually associated with emotional tensions which border on the abnormal, in our gifted group superior success is associated with stability rather than instability, with absence rather than presence of disturbing conflicts—in short, with well-balanced temperament and freedom from excessive frustrations".

The majority of intelligent children, and particularly the highly intelligent, tend to have interests well in advance of their physical age. Precociously concerned with such things as matters of origin, destiny and evil in the abstract, immature in experience but mature in logic, they rouse the anxiety, antagonism and jealousy of adults. They easily become negatively suggestible, and the illogical conduct of adults may lead to rebellion or to a gathering cynicism.

The difficulties of very able children are most likely to be marked within the middle years during the junior school period, and lessen as age increases the range of social movement, allowing them to seek companions of their own kind and as mastery of educational skills allows them to seek and find the intellectual challenge they need. Our system of progressive selection by academic attainment, though it has many defects, makes it more likely that the able child, even in the primary school, and certainly at the secondary and subsequent stages, will meet his equal and find stimulation. This does not mean that the problem of how the most able one, five or ten per cent of children, should be educated has been solved. This is a matter which is occupying the attention of educators in the United States as well as in Great Britain and Europe.

THERMODYNAMICS AND KINETICS OF SPONTANEOUS GENERATION

IN the current enthusiasm to put forward theories that provide a milieu rich in organic compounds for the spontaneous generation of life, little attention has been given to the quantitative aspect of the problem. One might estimate the rates of reactions producing such compounds, on one hand, from pertinent kinetic data; or one might use thermodynamics as a guide to the quantities of compounds expected, particularly in view of the long times available for approach to equilibrium. In a recent paper[1], however, Miller and Urey apply thermodynamic formulæ only to the equilibrium concentrations of inorganic raw materials in the primitive atmosphere; but they do not apply thermodynamics to the synthesis of organic compounds.

It seemed interesting to me to calculate the equilibrium concentrations of some amino-acids under the conditions postulated by Miller and Urey. For example, the first compound listed in their Table 2, glycine, is formed from the starting compounds by a reaction that may be written:

$$2\,CH_4 + NH_3 + 2\,H_2O = NH_2CH_2COOH + 5\,H_2$$

with an equilibrium constant of 2×10^{-40}. Substituting the partial pressures assumed by Miller and Urey (and taking p_{NH_3} as 0·04 atm.), the aqueous concentration of glycine is 10^{-37} mole/l. Similar calculations for more complex amino-acids yield smaller concentrations.

Now, of course, it is possible that, in an energy-rich medium, steady-rate concentrations can be maintained far from equilibrium. In such case the expected concentrations depend on the available mechanisms for synthesis and decomposition. Ultra-violet light is the most important source of energy to consider, being hundreds to thousands of times more abundant than electrical discharges or ionizing radiation. The atmosphere postulated is transparent to ultra-violet down to 2250 Å.

A glycine molecule formed in such an atmosphere is immediately vulnerable to radiation up to 3000 Å., absorbing in a part of the solar spectrum far more intense than that which produced it. Decarboxylation of activated glycine would presumably occur with a quantum efficiency of the order of unity. Thus, any glycine formed would be rapidly decomposed. Its absorption coefficient, about 0·15 cm.$^{-1}$-(moles/l.)$^{-1}$ at 2500 Å., and the intensity of ultra-violet below 3000 Å., about 0·01 cal./cm.^{2}/min., or 10^{15} quanta/cm.^{2}/sec., give it a half-life of about 30 days. This is much shorter than the half-time of transport from the stratosphere to the surface, now estimated from fall-out data as three years. Thus, 97 per cent of the glycine would be decomposed before it could reach the surface.

Miller and Urey hope to save the synthesized products by removing them from the reaction zone in the atmosphere to the ocean. But even after the glycine reaches the ocean, the victory is not won. Abelson[2] has discussed the possible stability of simple amino-acids throughout geological time; the important effect, however, is not thermal, but decomposition by ultra-violet radiation. The ultra-violet reaching the surface would penetrate to a considerable depth. To-day's sea water transmits 10 per cent of light of wave-length 2600 Å. to a depth of 6 in., and fresh water, which may be more nearly comparable to the primitive ocean, to as much as 3 ft. (ref. 3). In the mixed layer above the pycnocline, about 100 metres deep, glycine would have a half-life to ultra-violet destruction of about twenty years. Even assuming it to be mixed to the bottom of the ocean, with an average depth of 4 km., the half-life is only 1,000 years. These short lives for decomposition in the atmosphere or ocean clearly preclude the possibility of accumulating useful concentrations of organic compounds over eons of time.

The limiting concentrations to be hoped for can be estimated from the steady state between production and decomposition. The rate of formation of glycine by ultra-violet irradiation (1165–1470 Å.) from a mixture of methane, ammonia and water vapour may

be estimated from the reported work of Groth and von Weyssenhoff[4]. They were barely able to identify glycine and alanine in the product after exposure to 10^{21} quanta. On the assumption that they could detect 0·1 μgm. of glycine, this gives a quantum yield of 10^{-6}. The flux of solar ultra-violet radiation below 1500 Å. is given as 3·5 cal./cm.²/yr., which corresponds to 3×10^{11} quanta/cm.²/sec. Thus, glycine would be formed at a rate of 3×10^{5} molecules/cm.²/sec. During the average life-time in the atmosphere this could build up to 10^{13} molecules/cm.², or a partial pressure of about 10^{-14} atm. Allowing for 3 per cent to reach the ocean and the 1,000-year life there, the maximum concentration in the sea would be 10^{-12} molar.

This concentration is far from equilibrium. The actual concentrations realized would probably lie between the thermodynamic and the kinetic estimates, that is, between 10^{-27} and 10^{-12} molar; but even the highest admissible value seems hopelessly low as starting material for the spontaneous generation of life.

Consideration of other sources of energy, although they are very much weaker than the ultra-violet radiation, leads to similar conclusions. Thus, ionizing radiation may form complex products from simple reactants, but the more complex and highly organized compounds are more vulnerable to the same agent than their simple precursors. *G*-values of the order of unity are found for the decomposition of proteins by radiation[5]; whereas the formation of protein by radiation has not been observed.

The conclusion from these arguments presents the most serious obstacle, if indeed it is not fatal, to the theory of spontaneous generation. First, thermodynamic calculations predict vanishingly small concentrations of even the simplest organic compounds. Secondly, the reactions that are invoked to synthesize such compounds are seen to be much more effective in decomposing them.

Further, it must be remembered that both lines of argument become quantitatively of an overwhelmingly greater magnitude when organic compounds other than the very simplest are considered. From thermodynamics, the equilibrium concentration of glucose is 10^{-134} at unit activities of the component reactants. The values for the simplest proteins must be unimaginably small. Also, in agreement with the thermodynamic prediction, the kinetic steady-state concentration falls rapidly with increasing complexity of organic compounds, because (1) the quantum yield for their formation decreases; (2) at the same time their stability against thermal decomposition decreases; and (3) their opacity to ultra-violet radiation and decomposition by this means increases. The physical chemist, guided by the proved principles of chemical thermodynamics and kinetics, cannot offer any encouragement to the biochemist, who needs an ocean full of organic compounds to form even lifeless coacervates.

These estimates are not in conflict with the experimental results of Miller and others who have synthesized organic compounds with electrical discharges or ultra-violet light in the laboratory. They have merely used the well-known principle of increasing the yield of a reaction by selectively removing the product from the reacting mixture. But the fact that a chemist can carry out an organic synthesis in the laboratory does not prove that the same synthesis will occur in the atmosphere or open sea without the chemist. The second law of thermodynamics applies not only to inorganic gases in the atmosphere, but also to organic compounds in the ocean. Living cells may reverse the process, but in the absence of life, "die Entropie der Welt strebt einem Maximum zu".

D. E. Hull

California Research Corporation,
Richmond,
Cal.

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Dr. Hull's analysis of the production and stability of simple organic molecules in a lifeless Earth is a valuable contribution to the discussion on biopoesis. By introducing a quantitative discussion he has effectively narrowed down the range of possibilities and thus presented a much more definite problem to be solved. Others are far more competent to discuss the thermodynamic aspects of this communication, and I would rather question the conclusions that Dr. Hull draws from his arguments.

Even if we accept that small organic molecules, *a fortiori* larger organic molecules, are likely to exist in an atmosphere and open ocean only in very small equilibrium concentrations, it does not necessarily follow that the way of photosynthesis for the origin of even more complex compounds, or of life itself, is effectively barred. The fact that Miller and others have produced such compounds by radiation is, as Dr. Hull quite rightly points out, because these products are selectively removed from their zone of formation. It would seem to follow that if complex organic molecules were ever produced on a lifeless Earth, something similar must have occurred there. There must have been a process which removed a certain proportion of these molecules from their zone of reaction. Further, the same or another process must have concentrated them to the extent where they could enter into still more complex reactions. Such reactions did not necessarily require further energy sources to promote them. In other words, the original concept of the primitive soup must be rejected only in so far as it applies to oceans or large volumes of water, and interest must be transferred to reactions in more limited zones.

Even in the inorganic world, minerals are produced which involve very large degrees of concentration of rare elements, in fact, unless two atoms resemble each other in nearly every particular, as rare earths do, then somewhere in the world a mineral will be found containing mainly that element, however rare. The processes for the concentration of organic molecules may well be similar and equally effective. I have at various times proposed such a mechanism of just such concentration and shielding organic molecules originally formed in an ocean. My first was that of the concentration of molecules directly from sea water in estuarine clays[1]. More recently I have realized[2] that there exists a much more powerful method of concentration of all molecules which have either surface activity or which tend to concentrate in the neighbourhood of water surfaces, that is, effectively all molecules containing alkyl groups. A. T. Wilson[3] has directed attention to the processes of the concentration of organic material derived from dead organisms, first on the surface of the ocean and then, through the action of the wind in foam or

spray, along the coasts, thus providing nutriment for benthic organisms. The same processes would certainly have occurred in an abiotic sea in which any mineral hydrocarbons or their oxidized derivatives were to be found. The effectiveness of this process for concentrating tar will not be doubted by anyone visiting a beach in Britain to-day. The probability of the original presence of such hydrocarbons would be much strengthened if the ideas recently put forward by Mason[4] on the formation of meteorites containing hydrocarbons were accepted and extended to the outer layers of a primitive Earth.

By such a two-stage process, a relatively very small bulk concentration of synthetic molecules can be turned into a large concentration in specified areas. Further, once involved in clay, which absorbs such molecules readily, they will be completely shielded from ultra-violet radiation. A further mechanism of concentration of the smaller groups, particularly those containing nitrogen, will be provided by the presence of transition metal ions, notably those of iron, which may also play a part in primitive photosynthesis, as N. W. Pirie has pointed out[5]. One way of verifying or negating these hypotheses would be by extensive experimentation using large volumes of very dilute organic solutions and absorbing them on clay under controlled conditions. Until this is done, it is premature to accept any arguments, quantitative or qualitative, against the spontaneous formation of organisms, indirectly if not directly, from the primitive ocean.

J. D. BERNAL

Birkbeck College,
Malet Street,
London, W.C.1.

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AN ASSOCIATION BETWEEN DENTAL CARIES AND CERTAIN SOIL CONDITIONS IN NEW ZEALAND

By T. G. LUDWIG
Medical Research Council, New Zealand

W. B. HEALY
Soil Bureau, Department of Scientific and Industrial Research, New Zealand

AND

CAPTAIN F. L. LOSEE
(Naval Medical Research Institute, Bethesda, Maryland)
Medical Research Council, New Zealand

IN 1955 Hewat and Eastcott[1] reported that a relationship exists between prevalence of caries and certain soil conditions in New Zealand, and a general investigation is at present being conducted to determine the causal mechanisms responsible for this relationship.

One phase of this investigation involves the study of the effect on prevalence of caries of recent saline soils at Napier, Hawke's Bay. In 1931 the major Hawke's Bay earthquake resulted in the uplifting of a land mass some 60 miles long and at least 10 miles wide to heights ranging up to 9 ft. The epicentre of the disturbance was situated in the vicinity of Napier, where the shore-line was elevated from 6 to 8 ft., this resulting in the draining of more than 5 square miles of the extensive lagoon adjacent to the city. The saline soils[2] thereby exposed have since been brought into production and in comparatively recent years used for residential development. The preliminary results of our investigation in this area are presented in this report.

During 1954–55, dental examinations were undertaken of children resident throughout life in the adjacent cities of Hastings and Napier to establish a base-line whereby the effectiveness of the fluoridation of the Hastings water supply in reducing the prevalence of caries could be evaluated[3]. The results of these examinations showed that Napier children aged 5–8 years had a considerably lower caries experience than children of an equivalent age in Hastings, this difference being manifested in both permanent and deciduous dentitions. Napier children aged 6, 7 and 8 years had, respectively 57, 46 and 21 per cent fewer permanent teeth with caries experience than Hastings children of the same age (Table 1); and Napier children aged 5, 6 and 7 years had, respectively, 20, 14 and 6 per cent fewer deciduous teeth with caries experience. These differences in prevalence of caries were statistically significant at the 0·1 per cent level.

This finding was unexpected in view of the apparent similarity of conditions in the two cities. Both have populations of approximately 20,000 and are situated in the eastern part of Hawke's Bay, Napier being the

Table 1. COMPARISON OF CARIES PREVALENCE RATES IN PERMANENT TEETH OF HASTINGS, NAPIER AND PALMERSTON NORTH CHILDREN IN 1954–55 AND IN 1957

	Mean No. permanent teeth D.M.F.* per child			
	Hastings 1954–55	Napier 1954–55	Napier 1957	Palmerston North 1957
No. children examined	1,204	1,114	1,186	1,009
6 years	1·41	0·61	0·70	1·21
7 years	2·75	1·49	1·49	2·50
8 years	3·73	2·93	2·95	3·69
9 years	4·45	4·06	3·83	4·49
10 years	5·48	5·25	4·91	5·46

* D.M.F. = decayed, missing (extracted due to caries) or filled.

Table 2. Trace Element Levels (p.p.m.)* in Edible Parts of Vegetables Grown on Hastings and Napier Soils

Vegetable	Area	Mo	Al	Cu	Ti	Mn	Ba	Sr
Beans	Hastings	0	8–11	7·4–11	0	26–68	1·2	20–23
,,	Napier	1·1–9·5	34–95	4·5–6·0	1·0–4·0	7·6–11	0·3–11	7·6–13
Cabbage	Hastings	0	1·2–7·4	1·8–2·8	0	9·1–9·7	0·6–1·1	14–24
,,	Napier	0–3·7	3·0–15	1·9–3·6	0	5·3–10	0–1·1	15–26
Potatoes	Hastings	0	4·4–5·2	3·6–4·5	0·1–0·2	3·7–4·7	0·2–0·3	1·7–2·1
,,	Napier	0·2–0·4	4·0–5·0	2·4	0·1–0·9	2·8–3·3	0·1–0·4	1·4–3·8

* Results on oven dry basis. Zero levels mean that the element could not be detected by the method used.

chief port of the province and Hastings lying 8 miles from the sea and about 12 miles from Napier. Rainfall, hours of sunshine, socio-economic conditions, and racial composition of the populations are closely comparable. The reticulated water-supplies (normal fluoride content 0·15 p.p.m.) are drawn from the same artesian strata, and analyses have indicated that the normal mineral composition of the two supplies is similar (Healy, W. B., unpublished results). The cities have a common milk supply. Analyses of urine samples from Napier children have indicated that their lower caries experience is unlikely to be related to the ingestion of fluoride from fish or some unsuspected source, since the mean fluoride content of these samples was 0·15 p.p.m. (Malthus, R. S., unpublished results).

Dental examinations of Hastings and Napier children were repeated in 1957, and it was found that fluoridation at Hastings over a period of about 2½ years had reduced caries prevalence among children to approximately the same level as at Napier. To provide an additional check on the low caries experience of Napier children, dental examinations were made of children resident in the city of Palmerston North, which lies 110 miles south-west of Napier on a similar soil to that of Hastings. The results showed that, in 1957, Napier children up to the age of 10 years had a considerably lower caries experience than Palmerston North children of an equivalent age (Table 1), and that the relationship between caries prevalence in Napier and Palmerston North in 1957 was closely comparable to that between Napier and Hastings in 1954.

Both Hastings and Napier are situated on soils which are derived from similar alluvial materials. However, as a considerable area of soils in the vicinity of Napier has a recent marine history, this appears to be the most likely variable which may have influenced conditions between Napier and Hastings. To test this hypothesis, soil and vegetable samples were collected from five market gardens in the Napier area and from four in the Hastings area.

Analysis of the soils from the two areas shows little difference in total content of some twenty elements as determined by the spectrograph. Differences in soil properties such as exchangeable cations including magnesium and sodium, cation exchange capacity, carbon/nitrogen ratios, and available phosphorus, were comparatively minor in nature and probably reflect management practices of individual market gardens. Very definite differences in *p*H and per cent calcium carbonate were found. Hastings soils had *p*H's of 5·7, 6·0, 6·3, 6·7, while Napier soils had *p*H's of 6·4, 7·5, 7·7, 7·8, 8·1. The three soils with *p*H's above 7·5 contained shell fragments, and gave figures of 2–3 per cent for calcium carbonate.

The vegetables selected were potatoes, carrots, silver beet, French beans, green peas, cauliflower, cabbage, lettuce and tomatoes, since there is evidence to show that these include those most commonly used in the New Zealand diet (Cadell, P., unpublished results). The edible portions showed no marked differences in major elements, but spectrographic analysis of the ash showed some notable differences in trace elements. In general, Napier vegetables were higher than Hastings vegetables in molybdenum, aluminium and titanium, and lower in copper, manganese, barium and strontium. Typical results are shown in Table 2.

Trace elements other than fluoride have been suggested as possible factors in human caries. A high urinary selenium content, which reflects intake, has been associated with a high caries prevalence in humans by Hadjimarkos[4]. On the other hand, Ter Meulen[5], Adler and Straub[6], and Nagy and Polyik[7] have associated high molybdenum-levels in soils or in drinking water with low prevalence of caries in humans, while Adler[8] and Kruger[9] have developed a greater degree of caries resistance in rats by the administration of molybdenum during the period of mineralization of the rat molar. Stookey and Muhler[10] have reported that molybdenum increased fluoride retention in rats. Consequently, it is of considerable interest that our results showed that while molybdenum was detected in the ash of only one Hastings vegetable, it was present in that of the majority of Napier vegetables in amounts up to 9·5 p.p.m. The higher molybdenum content of Napier vegetables is attributed to its greater availability in Napier soils due in the main to higher *p*H.

At present it seems possible that a higher intake of molybdenum may be the prime factor responsible for the lower prevalence of dental caries among Napier children. However, additional studies involving these children, and extension of the investigation to animal experimentation and analysis of vegetables from home gardens, will be necessary before definite findings can be established.

A full report of this work will be published elsewhere.

The opinions expressed here are those of the authors themselves and are not necessarily those of the organizations represented.

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EFFECT OF OXYGEN ON THE INACTIVATION OF TRYPSIN BY IONIZING RADIATION

By Prof. J. A. V. BUTLER, F.R.S., and Dr. A. B. ROBINS
Chester Beatty Research Institute (Institute of Cancer Research: Royal Cancer Hospital), Fulham Road, London, S.W.3

A CONSIDERABLE number of discordant observations on the effect of oxygen on the sensitivity of enzymes to ionizing radiation is to be found in the literature. A recent extensive study of the inactivation of chymotrypsin[1] showed, somewhat unexpectedly, but in agreement with observations by Miss L. K. Mee[2], that in dilute aqueous solution the dose required to produce a given degree of inactivation was greater in the presence than in the absence of oxygen. In view of this it seemed desirable to examine the effect of oxygen on the sensitiveness of the solid enzyme, and it was found that in this case, with 15-MeV. electrons, oxygen had little effect.

In the case of a similar enzyme, trypsin, it has been reported[3] that with 2-MeV. electrons from a Van de Graaff generator, and with cobalt-60 γ-rays, the sensitiveness of the enzyme in the solid state is enhanced by oxygen by about 30 per cent. It therefore became necessary to examine further the behaviour of trypsin, to discover whether or not it behaves differently from chymotrypsin in this respect.

In the first place, experiments were carried out on dilute solutions, using techniques similar to those previously described[1]. Using 140-kV. X-rays, it was found that the degree of inactivation by a given dose was increased *in vacuo* by a factor of about 4 (Fig. 1). In the case of the solid enzyme, several series of experiments were performed, using different methods of preparing the solid phase. For accidental reasons, different sources of high-energy radiation had to be used in the various series. The results of these experiments are shown in Fig. 2. The experimental conditions are as follows:

(*a*) Trypsin films made by pumping off the water from a 1 per cent suspension of crystalline trypsin, supplied by the Worthington Biochemical Co. After the initial stage of evaporation, the liquid froze and the remaining water was pumped off. Irradiations were performed in either the 15-MeV. linear accelerator (300 rads per pulse of $1{\cdot}3 \times 10^{-6}$ sec.) at St. Bartholomew's Hospital Medical College, or the 4-MeV. (3 rads per pulse of $1{\cdot}5 \times 10^{-6}$ sec.) linear accelerator at the Mullard Research Laboratories, Salfords, Surrey.

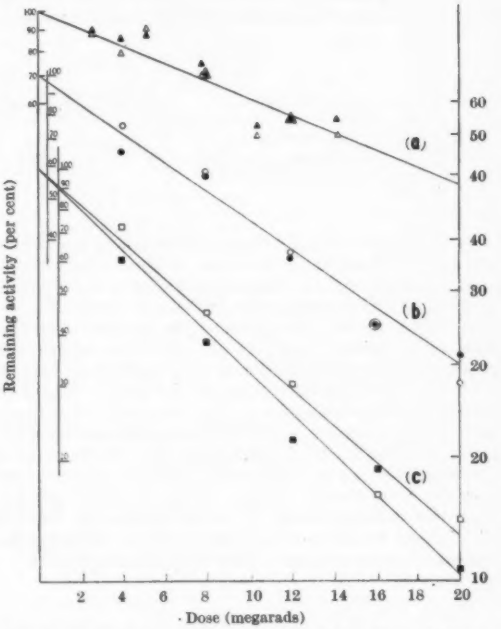

Fig. 2. Inactivation of solid trypsin by high-voltage electrons (conditions as in text). In oxygen: (*a*) △; (*b*) ○; (*c*) □. *In vacuo*: (*a*) ▲; (*b*) ●; (*c*) ■

(*b*) Crystalline trypsin in the form of a fine powder, as supplied by Worthington Biochemical Co. Irradiations carried out in the 4-MeV. linear accelerator (30 rads per pulse of $2{\cdot}5 \times 10^{-6}$ sec.) at the Wantage Radiation Laboratory of the Atomic Energy Research Establishment.

(*c*) Trypsin films made by dissolving the same trypsin in 10^{-3} *N* hydrochloric acid, freezing and pumping off the water. Irradiations as (*b*).

In all cases, when the enzyme was dry, the tubes were either sealed off *in vacuo*, after two flushings with argon, followed by evacuation to 0·05 mm. mercury pressure, or filled with oxygen and sealed. Enzyme activity was measured by Kunitz's casein method, as previously described[1].

The tubes were irradiated in pairs side by side, one evacuated and the

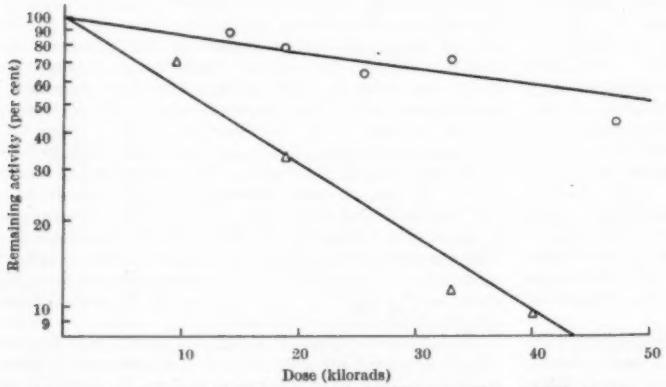

Fig. 1. Inactivation of trypsin in solution (0·028 per cent) by 140-kV. X-rays. ○, In air; △, *in vacuo*

other containing oxygen. It can be seen that in only 2 cases out of 17 did oxygen appear to increase appreciably the degree of inactivation as compared with the similar exposure *in vacuo*. (In some of the cases of series (*a*) the dosimetry appears to have been erratic, but this does not affect the conclusion stated.) In series (*c*) oxygen in fact decreased the inactivation to the extent of about 10 per cent.

It will be observed that the sensitiveness of the solid enzyme to irradiation is markedly modified by the mode of preparation in the solid film. Table 1 shows the mean values of D_{37} under the different conditions :

Table 1

Mode of preparation	D_{37} (megarads) In oxygen	*In vacuo*
a. Film from aqueous suspension	20	20
b. Crystalline powder	11·8	11·8
c. Film from 10^{-2} *N* hydrochloric acid	9·8	8·8
d. Film with 25 per cent cysteine-hydrochloride	17·4	38

It is not clear whether these differences of sensitivity are due to changes in the state of the trypsin molecule, when treated in different ways, or to some modification of other substances present in small quantities. The initial activity of the enzyme was unaffected by these treatments. An experiment was performed to see the effect of a protective substance, cysteine, on the sensitiveness of the solid. Added in relatively large amount to the solutions of trypsin before evaporation, cysteine hydrochloride (weight ratio, cysteine hydrochloride/trypsin = 0·25) reduced the sensitiveness by a factor of 4 *in vacuo* and by only 2 in the presence of oxygen. It is therefore possible that the enhancements of sensitiveness by oxygen which have been reported were due to it reducing the degree of protection by a protective agent present.

These and the previous experiments show that, in aqueous solution at least, oxygen is capable of acting as a protective agent. Various explanations of this can be suggested ; for example, in the presence of oxygen, the primary H radicals will be replaced at least to some extent by O_2H. It is possible that O_2H is less effective than H in causing inactivation because it may react preferentially on the protein at points remote from the active enzyme centre. The effect of oxygen might therefore be to change the nature of the reaction from denaturation, which has been demonstrated in aqueous solutions[1], to a relatively innocuous oxidation. In the solid there does not seem to be any reason for expecting a similar situation. Alternatively, it is possible that oxygen, on account of its 'radical' nature, might be able to draw off the unbalanced charges present within the protein and thus localize the damage caused by them.

We are much indebted to Prof. J. Rotblat, St. Bartholomew's Hospital Medical College, London, to Messrs. T. R. Chippendale and D. R. Perry, Mullard Research Laboratory, Salfords, Surrey, and to Dr. R. Roberts and Mr. J. McCann, Atomic Energy Research Establishments, Wantage, for arranging the irradiations and for help in dosimetry.

This investigation has been supported by grants to the Chester Beatty Research Institute (Institute of Cancer Research : Royal Cancer Hospital) from the Medical Research Council, the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund, and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service.

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DISTRIBUTION AND PREVALENCE OF *FUSARIUM MONILIFORME* SHELD. (*GIBBERELLA FUJIKUROI* (SAW.) WR.) PRODUCING SUBSTANCES WITH GIBBERELLIN-LIKE BIOLOGICAL PROPERTIES

By Prof. W. L. GORDON

Plant Pathology Laboratory, Canada Department of Agriculture Research Station, Winnipeg

THE fungus *Fusarium moniliforme* Sheld. (*Gibberella fujikuroi* (Saw.) Wr.) is now generally recognized as the cause of the 'bakanæ' disease of rice (*Oryza sativa* L.) which has long been known to occur in Japan. The most characteristic symptom exhibited by diseased plants is a marked increase in height. In recent years this type of disease in rice has been reported from several other countries[1].

Kurosawa[2] first demonstrated, in 1926, that sterile filtrates of the 'bakanæ' fungus contained an active principle or growth stimulant which could cause a marked stimulation of growth in rice seedlings. Nine years later, Yabuta[3] announced that the active principle had been isolated. He gave it the name 'gibberellin' after the name of the perfect stage *Gibberella fujikuroi* (Saw.) Wr. of the 'bakanæ' fungus.

F. moniliforme Sheld. is widely distributed geographically, particularly on graminaceous plants. However, relatively few investigations have been carried out to determine if isolates of this fungus from hosts other than rice produce substances with gibberellin-like biological properties, which will be referred to in this article as 'gibberellins'. The results of the investigations published at the present time indicate that isolates of this fungus from hosts other than rice usually lack gibberellins, but occasional exceptions have been encountered. The detection of an isolate of *F. moniliforme* Sheld. possessing growth-stimulating properties has been reported by Nisikado[4], by Bugnicourt[5] and by Borrow, Bryan *et al.*[6] from sugar cane (*Saccharum officinarum* L.) ; by Nisikado and Miyawaki[7] from cotton (*Gossypium* sp.) ; and by Bugnicourt[8] from maize (*Zea mays* L.). The present investigation was undertaken to obtain additional information on the geographical distribution and prevalence of strains of *F. moniliforme* Sheld. producing gibberellins.

One hundred and five isolates of *F. moniliforme* Sheld. were included in this investigation. Of these isolates, eighty-four were classified as *F. moniliforme* Sheld., seventeen as the variety *subglutinans* Wr.

and Rg., and four as the variety *anthophilum* (A. Br.), Wr. Most of these isolates were received through the Commonwealth Mycological Institute, Kew, England; the others were received directly from research workers located in various geographical areas. The various isolates were received from time to time over the past twenty-five years. They were originally isolated from a total of thirty-five species of plants, one insect species, and from five miscellaneous substrates. They originated in twenty-nine geographical areas (Table 1).

The host plant employed for the detection of 'gibberellins' was the simple recessive mutant of *Zea mays* L., designated 'dwarf-1'. According to Phinney, West *et al.*[8] the qualitative responses of the mutant 'dwarf-1', in the seedling stage to gibberellic acid, to gibberellin A_1, and to gibberellin A_2 are similar. Seed of the mutant 'dwarf-1' was obtained through the courtesy of Dr. Bernard O. Phinney, Department of Botany, University of California, Los Angeles, California.

Before the various isolates were tested, each was established as a monosporous culture on potato sucrose agar (2 per cent agar, 2 per cent sucrose) slanted in 'Pyrex' test-tubes. Each test-tube measured 20 × 150 mm. and contained 10 ml. of the medium. The monosporous cultures were allowed to grow at least 10 days before they were employed in tests.

The various isolates were tested for 'gibberellins' by the following method. Two drops of the detergent 'Tween-20' were added to 100 ml. of sterile distilled water. 5 ml. of this solution were added to each monosporous culture. After 2 hr. the solution was decanted off into a 'Pyrex' glass vial and applied to seedlings of the 'dwarf-1' mutant with a medicine dropper. A few drops of the solution were applied in the axils of the first two seedling leaves. The seedlings were treated in this way twice a day for two days, and then were allowed to grow a further three days before final observations and measurements were made. Four seedlings were treated with the solution from each culture in each test. Seedlings were grown in flats kept on a window ledge in the laboratory in which the variation of temperature was 24°–30° C.

The growth response of seedlings treated with the extracts obtained from each of the various isolates was determined by measuring the distance from the apex of the coleoptile to the ligule of the second seedling leaf, to the nearest millimetre. The average of the measurements made on the four seedlings treated with the extract of a single isolate was compared with that of four untreated seedlings (treated with sterile distilled water with 'Tween-20' added at the level mentioned previously). The average growth response to the extracts of the various isolates tested was found to range from 0 to approximately 500 per cent greater than that of the untreated seedlings. Those isolates designated in Table 1 as being 'active' produced a growth increase more than 25 per cent greater than that attained by untreated seedlings.

It will be observed from the results presented in Table 1 that an appreciable number of the isolates produced 'gibberellins'. Thirty-five of the 105 isolates tested were rated as 'active'. Of the 35 'active' isolates encountered, 23 were classified as *F. moniliforme* Sheld., 11 as the variety *subglutinans* Wr. and Rg., and 1 as the variety *anthophilum* (A. Br.)

Table 1. GEOGRAPHICAL DISTRIBUTION BY HOST AND SUBSTRATE OF 105 ISOLATES OF *Fusarium moniliforme* Sheld. (*Gibberella fujikuroi* (Saw.) Wr.) TESTED FOR THE PRODUCTION OF 'GIBBERELLINS' ON THE MUTANT 'DWARF-1' OF *Zea mays* L.

Geographical origin	Host and substrate	Species and varieties*	No. of isolates	
			'active'	'non-active'
Australia	*Triticum* sp.	F.m.	—	1
	Zea mays L.	F.m.s.	1	—
Canada				
Ontario	*Asparagus officinalis* L.	F.m.	1	—
	Prunus persica Batsch. rhizosphere	,,	—	1
	Zea mays L.	,,	4	4
	Zea mays L.	F.m.s.	3	—
	Pyrausta nubilalis (Hbn.) (insect)	,,	1	—
	Oil emulsion	F.m.	—	1
	Soil	,,	—	1
Manitoba	*Allium cepa* L.	,,	1	—
	Zea mays L.	,,	2	2
Saskatchewan	*Pinus sylvestris* L.	,,	1	—
Ceylon	*Oryza sativa* L.	,,	1	—
Egypt	*Citrullus vulgaris* Schrad.	,,	1	1
	Gossypium sp.	,,	—	1
	Lycopersicum esculentum Mill.	,,	—	2
	Zea mays L.	,,	—	2
	Soil	,,	1	—
Finland	*Betula* sp.	,,	—	1
Formosa	*Oryza sativa* L.	,,	1	—
Ghana	*Zea mays* L.	,,	—	1
Honduras	Soil	,,	—	1
India	*Arachis hypogaea* L.	,,	2	—
	Ricinus communis L.	,,	—	1
	Triticum sp.	,,	—	2
	Zea mays L.	,,	—	1
Iraq	Soil	,,	—	2
Israel	*Sorghum* sp.	,,	1	—
	Zea mays L.	,,	—	1
Jamaica	*Musa sapientum* L.	,,	—	1
Japan	*Oryza sativa* L.	,,	1	—
Kenya–Uganda	*Crotalaria juncea* L.	,,	—	1
	Saccharum officinarum L.	,,	—	1
	Solanum melongena L.	F.m.s.	1	2
Mauritius	*Saccharum officinarum* L.	F.m.s.	—	1
Netherlands	Culture solution	F.m.	1	—
Nigeria	*Elaeis guineensis* Jacq.	,,	—	2
N. Nigeria	*Pennisetum typhoideum* (L.) Rich.	,,	—	2
N. Rhodesia	*Zea mays* L.	,,	—	2
Nyasaland	*Coffea arabica* L.	,,	—	2
Pakistan	*Sorghum* sp.	,,	1	—
Portugal	*Linum usitatissimum* L.	,,	—	1
Sierra Leone	*Oryza sativa* L.	,,	1	1
South Africa	*Ananas sativus* Schult.	F.m.s.	1	—
S. Rhodesia	*Citrus* sp.	F.m.	—	1
	Dianthus caryophyllus L.	,,	—	1
	Nicotiana tabacum L.	,,	1	—
	Zea mays L.	,,	—	2
	Zea mays L.	F.m.s.	2	—
Tanganyika	*Musa sapientum* L.	,,	—	1
	Saccharum officinarum L.	F.m.	—	1
Trinidad	*Corchorus capsularis* L.	,,	—	1
	Crotalaria usaramoensis E. G. Baker	,,	—	1
	Crotalaria valetonii Backer	,,	—	1
	Hibiscus esculentus L.	,,	—	1
	Hibiscus sabdariffa L.	F.m.s.	—	1
	Maranta arundinacea L.	F.m.	—	1
	Rotboellia exaltata L.	,,	—	1
	Saccharum officinarum L.	F.m.s.	—	1
	Sorghum vulgare Pers.	F.m.	1	2
	Urena lobata (L.) Gaertn.	F.m.s.	—	1
	Zea mays L.	F.m.	—	1
	Copra	F.m.s.	—	1
Uruguay	*Zea mays* L.	F.m.	—	2
United States				
Colorado	*Zea mays* L.	F.m.s.	1	—
Illinois	*Zea mays* L.	F.m.	—	2
Minnesota	*Zea mays* L.	,,	—	1
	Zea mays L.	F.m.s.	—	1
Ohio	Sewage plant filter	F.m.	1	2
Virginia	*Zea mays* L.	F.m.s.	1	—
Washington	*Asparagus officinalis* L.	F.m.	—	1
	Hordeum brachyantherum Nevski	F.m.s.	1	—

* F.m. denotes *F. moniliforme* Sheld.; F.m.s., the variety *subglutinans* Wr. and Rg.; F.m.s., the variety *anthophilum* (A. Br.) Wr.

Wr. Although the majority of the isolates tested gave no indication of producing 'gibberellins', a sufficiently large number of 'active' strains was obtained to demonstrate that they are present in widely scattered geographical areas, and may be encountered on a range of host plants and on other substrates. Whether strains possessing 'gibberellins' originated in one geographical area, for example, Japan, or in various areas from time to time, several factors may have influenced their dissemination. One factor that would undoubtedly play an important part in their distribution would be seed-transmission. *F. moniliforme* Sheld. can be transmitted by seed, both internally and externally on the seed surface. The introduction of infested seed into areas where *F. moniliforme* Sheld. had not occurred would provide a rapid and effective means of dissemination of the fungus, and might also serve to introduce strains capable of producing 'gibberellins'.

The results obtained from the present investigation have provided information additional to that previously reported in the literature on the host-range and geographical distribution of strains of *F. moniliforme* Sheld. which produce 'gibberellins'. It appears likely to me that if investigations are carried on in the future along this line 'active' strains of *F. moniliforme* Sheld. will be demonstrated to be even more prevalent and widespread than the results of this investigation have indicated.

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LOWER TERTIARY MICROFOSSILS FROM McMURDO SOUND, ANTARCTICA

By Dr. LUCY M. CRANWELL (Mrs. WATSON SMITH)
c/o Geochronology Laboratories, University of Arizona, Tucson

Dr. H. J. HARRINGTON
Department of Geology, University of New England, Armidale, New South Wales

AND

I. G. SPEDEN
New Zealand Geological Survey, Lower Hutt

An understanding of the climatic, biological and geological histories of Antarctica is important to many studies, such as those on the origin and dispersal of the floras and faunas of the southern hemisphere, on Quaternary glaciations, and on continental drift and polar wandering. Contributions have been made in reports on the Cretaceous and Tertiary sediments and fossils of the Graham Land region[1], the latest being by Cranwell[2]; but except for those reports there has been a considerable hiatus in our knowledge for the reason why Cretaceous and Tertiary fossiliferous sedimentary rocks have not been found in other parts of the Antarctic. This article records the finding of apparently Lower Tertiary sediments in the McMurdo Sound district of the Ross Sea region. The sediments are rich in microfossils, many of which have not been found previously in regions south of Australasia.

Structural considerations suggested to geologists of the New Zealand Geological and Survey Antarctic Expedition, 1958–59, that Cretaceous and Tertiary sedimentary rocks, similar to those of other circum-Pacific lands, could be expected to occur beneath the floor of the Ross Sea, and beneath the ice-sheet covering the greater part of Marie Byrd Land. It was plain that if rocks of those ages occurred they would not be accessible to direct geological observation, being hidden beneath the sea and ice, but it was considered that fragments of them might have been carried by ice to moraines in the McMurdo Sound region and to sea-floor deposits in the Ross Sea. Cretaceous or Tertiary sediments had not been found in the moraines by geologists of the Scott and Shackleton expeditions early in this century, but new searches were made at several localities. At Minna Bluff and White Island, Harrington and Speden, working independently, found in the moraines fragments of light-coloured fine-grained calcareous sediments which were immediately compared with certain distinctive sediments deposited in New Zealand during a marine transgression which occurred between the Late Cretaceous and the Oligocene[3,4]. They particularly resemble some units of a widespread calcareous mudstone facies, of which representatives are the Burnside Mudstone and parts of the Amuri Limestone[5]; and it is very doubtful if they would have been considered significant, or even noticed, but for this resemblance. The collectors naturally considered, therefore, and with considerable confidence, that their samples would be about Late Cretaceous or Lower Tertiary in age, and probably in the Upper Eocene–Oligocene part of that range, but others were sceptical and considered that they could have been derived from some of the finer-grained beds of the Upper Palæozoic and Lower Mesozoic Beacon Sandstone Formation[6,7]. Some specimens contain minute shell fragments, and one contains a fragment identified by Speden as part of a worm tube (? *Rotularia* sp.), which is not of value in age-determination (specimen *MS* 29, 7505*A*, New Zealand Geological Survey collections).

Afterwards, Mr. G. H. Scott, New Zealand Geological Survey, identified poorly preserved Foraminifera representing four genera in 7505*A*, a light-grey sandy mudstone from Minna Bluff. He states that "little can be said with confidence about the age of

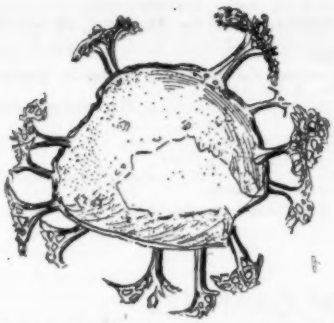

Fig. 1. *Hystrichosphaeridium* sp. from a mudstone fragment in a Minna Bluff moraine. Diameter, including appendages, about 100μ. This form has strong affinities with the *H. complex* group

the sample. In New Zealand *Angulogerina* of the type found in it does not occur prior to the Whaingaroan (Lower Oligocene); elsewhere the genus has Eocene representatives of the type discussed here, for example, *multicostata* Berquist from the American Jackson Formation, but Paleocene representatives seem to be lacking. It is probably correct to regard the *Angulogerina* of this fauna as indicating a post-Paleocene age. The occurrence of *Globoquadrina*, if correctly identified, would reinforce this age assignment, as this genus first appears in the Oligocene in New Zealand (Waitakian) and Australia".

The results obtained by Mr. Scott were not conclusive, but strongly supported the opinion held by Harrington and Speden, on lithological evidence, that the specimens are younger than Upper Palæozoic or Lower Mesozoic, and close to Eocene or Oligocenein age.

Fragments of specimens 7505 and 7505*A* were sent to Cranwell, and a small pollen component was recovered along with a wealth of hystrichosphaerid (Fig. 1) and dinoflagellate forms. Further study will be needed before adequate comparison can be made with the Australian and New Guinea microplankton described since 1953 in the pioneer researches of Cookson, Deflandre and Eisenack[8–11], and correlated by them, in some cases, with European finds in particular. At present it appears that faunal and floral elements point to some Cretaceous, or earlier, admixture, but much of this may be traced to redeposition, or to misinterpretation caused by our lack of knowledge of the time-range of hystrichosphaerids recorded solely, or with few exceptions, from the Cretaceous or earlier. Only in 1958 did Cookson and Eisenack begin to report Tertiary occurrences for some of these key Mesozoic forms.

The pollen grains are few in number but well preserved, though tending to stain lightly; they

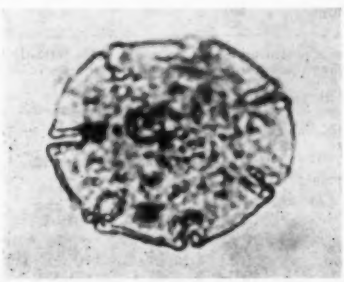

Fig. 2. Pollen-grain of *Nothofagus* sp. from a mudstone fragment in a Minna Bluff moraine. Diameter about 26μ

belong to groups already known at Seymour Island[2] from macrofossil and microfossil remains; but none of the types so far recognized is identical. No fern spores, no fungi, no cuticles and only a few tracheids (single broken shreds) were found. Species of southern beech (*Nothofagus*) predominate (Fig. 2), and there are ties, on one hand, with New Guinea, Australia, New Caledonia and New Zealand forms, either fossil or living, and on the other, a link, stronger than in the Seymour Island material, with certain characteristic South American forms. The conifers occur in lower frequencies and their types have not yet been sorted out to our satisfaction. Palmoid and proteaceous types occur, and a few others have been noted. The microplankton contains plani-spiral microforaminifera, and there are a few fragments which suggest alcyonarian spicules.

Dating of the pollen cannot yet be fixed: it is not likely to have originated earlier than the mid-Cretaceous, judging by work done in New Zealand by Couper[12], and it is probably not as recent as the Miocene cooling in the Graham Land region described by Adie[1]. As in the Seymour Island material, the pollen absences (for example, Compositae) might be taken to eliminate Miocene possibilities, but it must be remembered that the assemblage can only be a weak representative of the original communities since large grains, and insect-pollinated types, are less fitted to travel great distances in air currents, and we have here no suggestion of carriage by muddy rivers. The total evidence, of course, tends to indicate an age between the Late Cretaceous and the Oligocene, as indicated by the lithology, and the Foraminifera recorded by Mr. Scott.

The low frequencies—only a few grains per slide—and the restriction to small wind-pollinated types (mainly less than 35μ), coupled with the wealth of hystrichosphaerid and dinoflagellate remains, strongly indicate settling in offshore waters of normal salinity and low turbidity (cf. Orinoco Delta deposits described by Muller[13]) and at some distance from the land areas where temperate forests yielded the pollen rain. These conditions could well be matched during a marine transgression across a shallow continental shelf bordering a low, easily flooded land-mass, or by the existence of shallow marine troughs between island groups in a time of base-levelling and relative tectonic calm. It is conceivable, by comparison with New Zealand and other circum-Pacific lands, that island groups and marine troughs existed that were precursors of the ridges and depressions discovered buried beneath the ice of the Ross Sea–Weddell Sea region, as the result of a magnificent series of traverses by United States seismic-sounding parties[14].

In addition to the notes already given, we wish to stress that these are the first records, so far as we can ascertain, of dinoflagellates, hystrichosphaerids, microforaminifera, scolecodents (annelid jaws: very rare), ? alcyonarian spicules, pollen, tracheids and spores (undetermined) from this area, and the first fossil occurrences of several of these groups south of Australasia.

Thanks are extended to the United States Navy for transport to Antarctica and localities in the Ross Sea region; to Messrs. A. C. Beck, E. B. Fitzgerald and other members of the expedition for co-operation in the field work under arduous conditions and for sharing notes and views; to Mr. G. H. Scott, New Zealand Geological Survey, for his work on the Foraminifera; and to Prof. Terah Smiley and his staff at the Geochronology Laboratories, University

of Arizona, and particularly to Mr. Bernard C. Arms for running our unpromising samples by a new silica depressant method[15].

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AGE OF EMPLACEMENT OF GRANITES

By Dr. W. COMPSTON, Dr. P. M. JEFFERY and G. H. RILEY
Department of Physics, University of Western Australia, Nedlands, Western Australia

RADIOACTIVE age determinations are usually made on the separated mineral components of a rock rather than on the whole rock itself, and the age of emplacement of the latter, regarded as the time at which the various radioactive elements first became fixed into different mineral species, is then inferred from the ages of the minerals. This procedure is valid only when at least one of the minerals has remained a closed chemical system since first crystallization. As there is no independent means of recognizing a closed system, it becomes necessary in practice that the ages of all constituent minerals should agree before much confidence can be placed in any inferred age of emplacement. Even with this stipulation, the result is not conclusive, since it will also be met by the minerals of a completely recrystallized rock.

Several instances[1,2] have been reported in metamorphosed granitic rocks in which biotite yields a lower rubidium–strontium age than microcline, and each mineral in addition possesses different potassium–argon and rubidium–strontium ages; one case[3] was recently cited of a microcline which lost radiogenic strontium during metamorphism. The age of rock emplacement in such cases becomes less and less founded on verifiable fact, and some alternative means of determining this age is most desirable.

The fact that in some cases mineral grains are evidently open chemical systems does not necessarily mean that the rock as a whole must also be an open system. This was considered by Schreiner[4], who found experimentally that 'total rock' ages by the rubidium–strontium method were in reasonable agreement with pure mineral ages for the red granite of the Bushveld Complex. We have recently analysed total rock samples of a metamorphosed granite and associated pegmatites from Mundaring, Western Australia, in which pegmatitic muscovite and microcline were the only minerals to retain an old rubidium–strontium age. Although each total-rock sample was found to possess a different ratio of rubidium to strontium, they all gave the same age for a unique value of the ratio initial strontium-87/strontium-86, which was also the age given by the muscovite. We believe that this figure is the age of emplacement of the granite, and that total-rock analysis represents both the simplest and least ambiguous method of determining this age.

Analytical results for five total-rock and four mineral samples are listed in Table 1. The quantities directly measured for each sample are the present-day ratio strontium-87/strontium-86, using an unspiked aliquot of the sample in solution, and the ratio rubidium-87/strontium-86 by isotope dilution using other aliquots. (We find that calculation of the ratio strontium-87/strontium-86 from spiked strontium data is unreliable for samples rich in common strontium, due to variability in the ratio strontium-88/strontium-86 in the sample, and to enhanced magnification of mass-spectrometric random errors.) From the expression:

$$\text{Age} \simeq \frac{^{87}\text{Sr}^*}{\lambda^{87}\text{Rb}} = \frac{^{86}\text{Sr}}{\lambda^{87}\text{Rb}}\left[\left(\frac{^{87}\text{Sr}}{^{86}\text{Sr}}\right)_{\text{present}} - \left(\frac{^{87}\text{Sr}}{^{86}\text{Sr}}\right)_{\text{initial}}\right]$$

where $^{87}\text{Sr}^*$ denotes radiogenic strontium and λ the decay constant of rubidium-87, it may be seen that the ratio $\lambda^{87}\text{Rb}/^{86}\text{Sr}$ has been the time-rate of change (approximately) in the ratio $^{87}\text{Sr}/^{86}\text{Sr}$ of the sample for whatever period it has remained a closed chemical system. The term $(^{87}\text{Sr}/^{86}\text{Sr})_{\text{initial}}$ denotes the ratio for the system at the time it was generated: it constitutes in fact another unknown quantity besides age in the rubidium–strontium method. Mathematically, however, we may at first avoid attaching physical significance to this term by regarding it as the independent variable in an equation

Table 1

Mineral Data and Ages

	Rubidium (p.p.m.)	Common strontium (p.p.m.)	Radiogenic strontium (p.p.m.)	Age (m.yr.)
Muscovite from pegmatite	1,834	5·8	19·8	2,700
"	2,163	5·3	23·2	2,690
Microcline" from pegmatite	1,125	27·8	10·3	2,300
Biotite from pegmatite	1,309	6·5	3·43	670
Micromuscovite from granite	501	144	5·48*	2,730

* Based on a strontium-87/strontium-86 ratio initially 0·70. Ages calculated using rubidium-87 decay constant of $1{\cdot}386 \times 10^{-11}$ yr.$^{-1}$.

Total-rock Data

	Rubidium (p.p.m.)	Total strontium (p.p.m.)	$^{86}\text{Sr}/^{87}\text{Rb}$	$^{87}\text{Sr}/^{86}\text{Sr}$
Granite 1	165·5	129	0·266	0·842
Granite 2	186	129	0·236	0·864
Granite 3	226	106	0·157	0·945
Biotite–pegmatite	194	71	0·122	1·010
Muscovite–pegmatite	331	21·4	0·018	2·85

for age. The straight lines as given by the above expression have been plotted for each sample in Fig. 1. They converge very distinctly to the region:

$$^{87}Sr^{*}/^{87}Rb = 0{\cdot}0383\ ;\quad ^{87}Sr/^{86}Sr = 0{\cdot}700$$

On the assumption that the strontium throughout this granite was initially uniform in isotopic composition, it may be inferred now that: (i) each total rock sample has indeed remained a closed system with respect to rubidium and strontium back to the point in time defined by these co-ordinates; (ii) the variable ratio of strontium to rubidium is due to an initial inhomogeneity in the granite; and either (iii*a*) the age corresponding to this point, 2,700 m.yr., is the age of emplacement of the granite, or (iii*b*) 2,700 m.yr. is the age at which all earlier formed radiogenic strontium in the system diffused out from the rubidium-rich minerals and became completely mixed with common strontium throughout the granite. In either case, the ratio strontium-87/strontium-86 of the system at this time was 0·700 throughout.

The alternatives in inference (iii) simply represent the fundamental ambiguity in radioactive age determinations mentioned initially, which is present even in a rock, the minerals of which all give the same age as the whole-rock samples. However, in the future it may be possible to eliminate one of these alternatives by considering the absolute value of the ratio strontium-87/strontium-86 at the point of concurrence. Meteoritic strontium, the strontium-87/strontium-86 ratio of which is about 0·685 (ref. 5) presumably represents the source from which the present-day common strontium of the crust evolved. If the value of the latter is approximately 0·715 (a little greater than the average present-day ratio in basic igneous rocks as measured in this laboratory), and if its evolution has been approximately linear with respect to time, then a granite formed from average crustal strontium 2,700 m.yr. ago should possess an initial strontium-87/strontium-86 ratio of about 0·700. This in fact is the value found above, so that the granite total-rock age could be interpreted on this picture specifically as the age of emplacement. However, the assumptions concerning the sampling and evolution of crustal strontium, though reasonable, have not yet been substantiated experimentally.

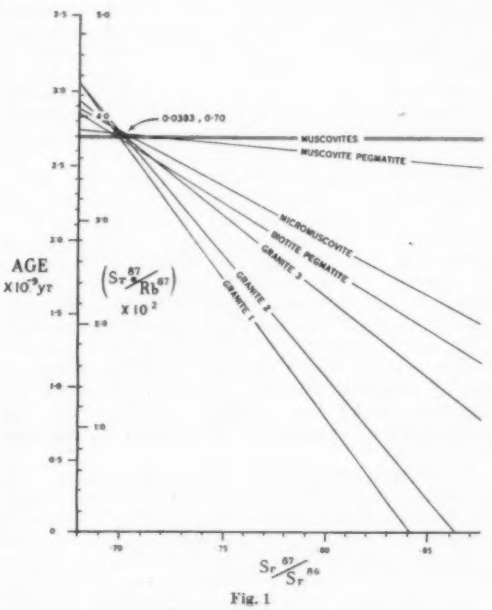

Fig. 1

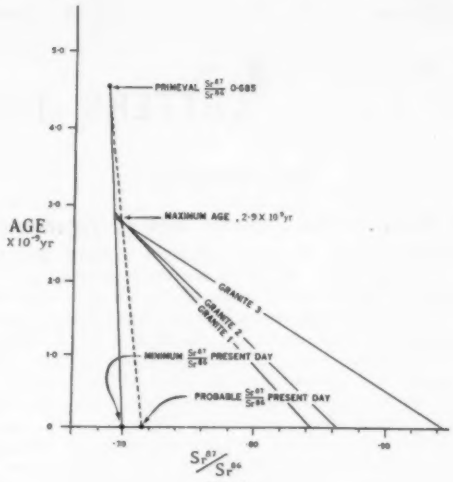

Fig. 2

In any event, it is possible still to set an upper limit to the age of the granite, if it was formed directly or indirectly by some process of differentiation from mantle material. Taking 0·700 as the value of the ratio strontium-87/strontium-86 for the present-day mantle, and again assuming a linear evolution of this ratio from primeval strontium, then the maximum age of the granite becomes 2,900 m.yr. (Fig. 2). Even in the most unlikely case that essentially primeval strontium was incorporated with the granite, its age still could be no greater than about 3,000 m.yr.

One further result follows if 2,700 m.yr. is taken as the age of emplacement of the granite. Fig. 1 shows that the pegmatites also have this age, thereby confirming the widely held premise that pegmatites can form immediately on the solidification of a granite.

Finally, as regards the ages of the mineral, we wish to emphasize that none of the potassium feldspars from these granitic rocks exhibits complete preservation of the 2,700 m.yr. event. Pegmatitic microcline comes closest at 2,300 m.yr., whereas granitic microclines show any 'age' down to about 650 m.yr., which is also the age registered by all biotites. Pegmatitic muscovite and micromuscovite, formed in the granite during saussuritization of the plagioclase feldspar, alone show complete retention. The latter shows, incidentally, that saussuritization was definitely a late-stage magmatic process in this case.

Full details of these age determinations will be reported elsewhere. We are grateful to Dr. A. F. Wilson and Mr. I. Martin, of the Department of Geology, for helpful discussion and practical assistance, and to the Research Grants Committee of the University of Western Australia for financial support.

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LETTERS TO THE EDITORS

GEOPHYSICS

A Telemetered Seismic Net in Tasmania

Work during the past eighteen months towards the establishment of a telemetered seismic net in Tasmania has involved research in which electronics and seismology have been brought into close contact. Information about the net itself will be published in detail elsewhere, but the purpose of this communication is to describe new ideas which have arisen from contact between the two fields. The developments have followed two lines. First, the application of electronic amplifiers and the principles of feedback servomechanisms to the design and construction of seismographs. Secondly, and perhaps more important, has been the consideration of problems in observational seismology from the point of view of information theory as the problem of extracting a message from a noisy background. This, by analogy with other fields, has led to the consideration of methods whereby the discrimination of seismographs against background noise could be improved.

Our electronic seismograph uses a transducer with variable reluctance, but with an a.c. magnet; the output then consists of amplitude-modulated alternating current which is easy to amplify and telemeter. The response of the seismograph can be readily controlled by feeding back to the pendulum, in the correct proportion, the demodulated output of the amplifier together with its derivative and integral. For example, Fig. 1 shows the performance of conventional seismographs as given by Willmore[1], to which we have added for comparison the performance of our seismograph.

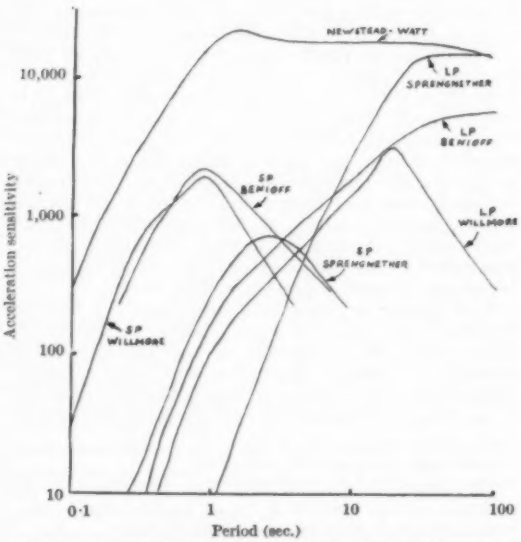

Fig. 1. Diagram showing performance of conventional seismographs given by Willmore (ref. 1) to which we have added for comparison the performance of the a.c. seismograph

With the particular combination of feedback used, it will be seen that it acts as an accelerometer between 1 and 100 sec., and its response is above the envelope of the performance shown for the conventional seismographs. Now that the performance is well under control, the question arises as to the best way to adjust it for various purposes. Seismologists have traditionally thought in terms of periods and damping, and various adjustments[2] are used for particular instruments, most of which are highly resonant. As shown, our seismograph has been adjusted as a broad-band accelerometer; this, however, is purely for comparison and it could equally well be adjusted in other ways. The problem of what characteristics it should in fact have to obtain optimum performance depends on the statistics of the signal and the message, and these have received only scant study by seismologists. For the present, therefore, we propose to record the whole of the information contained in the band and experiment with filtering and other processes on the record itself. Provided that external noise is the factor which limits the performance, this procedure will not affect the signal-to-noise ratio in the recorded information.

Willmore[3] has considered the limitation of sensitivity in seismographs which do not use amplifiers. If amplifiers are used, then the limitations he has discussed do not apply—the absolute level of sensitivity shown in Fig. 1 was arbitrarily chosen for the purpose of comparison, and it could be increased by several orders of magnitude if required. When sensitivity is not the limiting factor, the signal-to-noise ratio becomes apparent as the limit of resolution, and it is necessary to consider various noises. Seismologists do not appear to have adopted standard methods of specifying ground movements, although the displacement of the ground is often quoted in microns. Without a more complete knowledge of the spectrum, this is not very useful for comparing instruments which are to be used at other frequencies, and in what follows we shall mean the equivalent displacement of the ground in microns at 1 c./s., the figures given being orders of magnitude only. Background ground movement depends on the site and the particular day, and may range from 0·1 to 10 microns. In our seismograph, amplifier noise corresponds to a minimum detectable signal of 10^{-5} micron. This should be increased by an unknown amount to take account of Barkhausen noise in the transducer. We have not been able to estimate the amount of this noise, but indications are that it is very small. There remains finally the ultimate limit of seismometry—the Brownian motion of the pendulum—which we roughly estimate for our seismograph to correspond to a signal of less than 10^{-5} micron.

At present, background noise predominates; but preliminary experiments conducted in Hobart suggest that noise recorded at sites separated by a few miles is largely uncorrelated. If this is so, it will be possible to resolve discrete signals out of the background by measuring the correlation between signals received at different sites. This idea was developed for radio

astronomy, and although the techniques are more difficult in the seismic case they are still possible. We are designing and propose to construct a correlation machine to measure in pairs the correlation between the records of the various stations in our net.

Initially we are using pen-and-ink recording on paper; however, we are working simultaneously on an arrangement using magnetic recording on tape with electronic reduction of the information. The magnetic recording will be done at tape speeds of ½ in. per sec. and replayed at much higher speeds. This will reduce the time of interpreting the records, and by raising the significant frequencies will make filtering and other analogue operations on these signals much easier. For example, it will be possible immediately to obtain the spectra of various natural and artificial seismic events from the tape recordings, and also to produce records from the broad-band recordings identical with those which would have been produced by highly resonant seismographs located in the band. Eventually, it will be possible to produce tapes which can be fed into digital computers for processing in various ways.

We wish to acknowledge the help provided by Prof. S. Warren Carey, professor of geology in the University of Tasmania, who initiated the idea ofthe telemetered net and who has also provided many helpful discussions and ideas.

GORDON NEWSTEAD
P. A. WATT*
Department of Electrical Engineering,
University of Tasmania, Hobart.

* General Motors Holden Research Student.

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METEOROLOGY

Sodium/Potassium Ratio in Rain-water

DR. B. C. V. ODDIE has commented[1] on a portion of my recent article "Surface of the Ocean as a Source of Air-Borne Nitrogenous Material and Other Plant Nutrients"[2] with particular reference to the sodium/potassium ratio in rain-water. In this article I presented results of the analysis of New Zealand snows and proposed that there exists on the surface of the ocean a very thin layer which is rich in potassium, nitrogenous material and other substances as a result of the activities of micro-organisms. It was suggested that portions of this layer are transferred to the atmosphere by the bursting of bubbles in 'white caps' and thence to the land. I referred to the fact that the sodium/potassium ratio in rain is often markedly lower than that in bulk sea-water and suggested that the excess potassium was coming from the surface layer described above. Oddie directs attention to the fact that the low sodium/potassium ratios commonly recorded at inland collecting stations are scarcely ever observed at exposed coastal stations in Europe and North America and states that in general the more maritime the situation of a station the more closely does the ratio approximate to that of sea-water (that is, 27). He makes reference to results from the Shetland Islands. Oddie further states, however, that this is evidence against my suggestion, at least for European and American rains.

Table 1. SODIUM/POTASSIUM RATIOS OF COASTAL NEW ZEALAND SNOWS

	Distance from sea (miles)	Sodium (p.p.m.)	Potassium (p.p.m.)	Sodium/potassium
Snow collected May 3, 1958, on Mt. Egmont at 6,000 ft.	20	0·68	0·24	2·8
Snow collected April 27, 1958, on Tasman Glacier at 7,000 ft.	25	0·20	0·18	1·1
Snow collected August 22, 1958, at Temple Basin, Arthurs Pass, at 5,000 ft.	30	0·04	0·02	2
Sea-water		11,000	410	27

In the case of snows (Table 1) collected close to the sea on the west coast mountains of New Zealand the potassium must come from the ocean as there is no industry or for that matter land to act as its origin. In the case of the European and North American rains the problem perhaps is complicated by fuel combustion, industry, etc., and it is not possible for me to say how much of the excess potassium comes from the ocean or from other sources. However, Oddie is scarcely justified in ruling out my hypothetical mechanism as a source of some of the excess potassium in European rains on the evidence that the sodium/potassium ratio approaches 27 as one approaches an exposed coast. In such considerations one must rather consider the total amount of potassium deposited each year. To illustrate this, let us take Oddie's own example of Sweden[3]. The yearly integrated sodium/potassium ratio decreases from 10 on the coast to 1·7 at 200 km. from the sea. If instead the potassium deposited per annum is taken it is seen to be[2] 3·8 kgm./har. on the coast dropping to 2·4 kgm./har. 200 km. inland. The high sodium/potassium ratios on the coast are caused not by low potassium deposition but by high sodium deposition due probably to wind-blown bulk sea-water. On the coast in New Zealand this can be very great (near Wellington airport (Rongotai), for example, 210 lb./acre/yr. of chlorine are deposited[4]); this will raise the sodium/potassium ratio toward that of bulk sea-water. This effect (as does the sodium/potassium ratio) drops off rapidly with distance, presumably due to the large size of the wind-blown sea-water drops. In my discussion of the snow analyses[2] I corrected for the "wind-blown sea-water effect" by considering only "the excess potassium" which was defined thus:

excess potassium ion concentration = potassium ion concentration − 1/27 sodium ion concentration

Nevertheless one can, as is seen from Table 1, obtain snow samples near the coast with sodium/potassium ratios as low as 1–3 which Oddie claims are only found at inland collecting stations. It should be noted, however, that these were all taken at high altitudes, and it is possible that the heavier wind-blown bulk sea-water salt does not reach these altitudes. Another point is that in collecting fresh snow one obtains the precipitations of only an hour or so, whereas if samples of rain-water are collected over relatively long periods (weeks) an integrated value is obtained. Thus any period of high wind will deposit wind-blown bulk sea-water and so raise the average sodium/potassium ratio of the rain. I would suggest that individual rain showers be collected over short periods of time (for example, ½ hr.) at the European coastal stations in question (for example,

Lerwick). It seems probable that some of these (collected on days with no high wind) will give sodium/potassium ratios approaching those of inland stations.

A. T. Wilson

Victoria University of Wellington,
Wellington,
New Zealand.

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PHYSICS

Velocity of Light in a Magnetic Field

One consequence of classical electromagnetic theory is that the velocity of light *in vacuo* should be unaffected by superposed magnetic or electric fields; this conclusion is worth checking experimentally whenever a sufficient advance occurs in precision of observation. As regards the constancy of the velocity of light through a vacuum in the presence of a transverse magnetic field, the most precise observations higherto made are probably those of Banwell and Farr[1]. These investigators showed in 1940 by an interferometric technique with photoelectric recording that in a field of 20,000 oersted the change of velocity, if it existed, was unlikely to be much more than an increase of about 30 cm./sec.; their probable error was about 18·6 cm./sec.

Recent developments[2] in the photoelectric detection of small deflexions of a beam of light have made it possible to look for deviations of such a beam when passing through a transverse magnetic field shaped to resemble an optical prism; this shape of field was first applied by Rabi[3] to improve the accuracy of the Stern–Gerlach technique.

The photoelectric detection system has a root-mean-square error of about $1{\cdot}4 \times 10^{-11}$ radian for a bandwidth of 1 cycle/sec.; it has been used to look for deviations of the light beam when a field of about 8,000 oersted is switched on and off for alternate 10-sec. periods. By taking 400 observations, giving a total observing time of about 8,000 sec., the error in comparing the directions of the light beam before and after passage through the prismatic field has been reduced to a root-mean-square value of $5{\cdot}5 \times 10^{-13}$ radian. The average change in direction actually found was $1{\cdot}8 \times 10^{-13}$ radian, away from the apex of the prism; since this was only about one-third of the root-mean-square error, we may conclude that no significant deflexion was observed. For nearly one-half of all the observations, unpolarized white light was used; in the remainder, the same light was plane polarized, with its electric vector first parallel to the magnetic lines of force, and afterwards at 45° to this direction.

The effective prism angle was about 100°; the angular root-mean-square uncertainty of $5{\cdot}5 \times 10^{-12}$ radian therefore corresponds to a root-mean-square uncertainty in the constancy of velocity (or of refractive index of the magnetic field) of about 2·3 parts in 10^{13}. Should the velocity of light be subject to a simple change by as much as 100 micron/sec. in a transverse field of 8,000 oersted, the change ought to have been detected.

While this negative result may have little consequence, the figures indicate that optical deflexion measurements by photoelectric methods can be comparable in precision with maser experiments[4] and Mossbauer techniques[5].

R. V. Jones

Department of Natural Philosophy,
Marischal College,
Aberdeen.

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'Prize': a Pre-ionized 'Theta' Pinch

Work has recently begun here on an experiment designated 'Prize'.

'Prize' is an electromagnetic shock-tube using pre-ionization in the *Z* direction followed by a theta pinch; its main function is to form a high-temperature plasma in deuterium gas by shock heating[1] without the ubiquitous trapped magnetic field usually associated with theta pinches and described elsewhere[2,3].

In the conventional theta pinch the magnetic field is able to penetrate the cold gas before the initial formation of the current sheet. This trapped magnetic field reduces the temperature of the imploding shocked gas since work is done in compressing it; the field also gives rise to instabilities on the second half-cycle of the discharge[3]. In earlier experiments at Foulness other methods of eliminating trapped magnetic field were tried including the use of a d.c. bias magnetic field to cancel out the trapped field and also plasma injection using a Kolb type '*T*' tube. In 'Prize' a thin annular cylinder of high-conductivity plasma is formed by a linear pinch before the azimuthal currents in the theta piece set up a longitudinal magnetic field. The magnetic piston set up by the currents in the theta piece then drives the thin annular current sheet towards the axis of the shock tube and, due to the high conductivity of the initial pinch, the diffusion of magnetic field into the plasma is considerably reduced.

Figs. 1 and 2 show the geometry of 'Prize'. The linear *Z* pinch is set up between the annular electrodes at each end of the quartz tube; the 'backstrap' required to form the initial axial current discharge near the walls of the discharge tube, at the point of minimum inductance, is the thin slotted copper cylinder on the outside of the tube. The cylinder is,

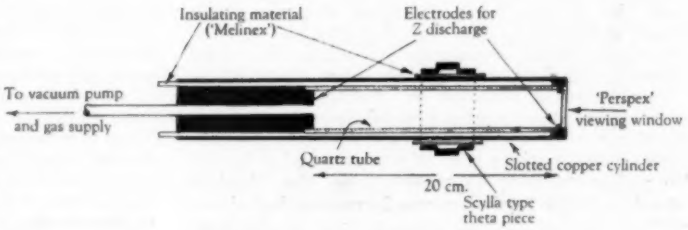

Fig. 1. Cross-section of 'Prize'

Fig. 2. 'Prize'

of course, slotted to allow the magnetic field set up by the theta piece to penetrate into the quartz tube.

Fig. 3 shows a schematic diagram of the circuitry associated with 'Prize'. Switching has been designed so that the linear pinch does not move appreciably before the theta voltage is applied. The switching arrangement is a simple but effective explosive sandwich layer consisting of three copper strips separated by 'Melinex', the order of the strips being, from top to bottom, *Z* live, common earth, theta live with the explosive uppermost. This ensures that the theta voltage is applied approximately 0·1 μsec. after the *Z* voltage.

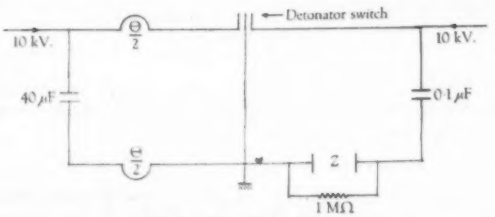

Fig. 3. Schematic diagram

Our early experiments have been concerned with the synchronization of events, and for this purpose we have used convenient values of voltage, 10 kV., and stored energy, theta 2 kilojoules, *Z* pinch 5 joules, and a theta piece consisting of a single copper turn. Figs. 4 and 5 show streak camera records (radius time curves) of the motion of the shock fronts for 'Prize' fired with and without the *Z* pre-ionization and an initial deuterium pressure of 1 mm. Fig. 4 shows no trapped magnetic field with a completely converging shock system on the first half-cycle of the theta discharge and Fig. 5 appreciable trapped magnetic field.

Figs. 4 and 5

We are now entering the second phase of the experiment in which we intend to apply more energy to a Scylla[4] type theta piece.

R. D. Medford
A. L. T. Powell
J. D. Herbert
R. C. Pottinger
J. K. Wright

Atomic Weapons Research Establishment,
Foulness,
Southend-on-Sea,
Essex.

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Ultra-High Resolution γ-Ray Resonance in Zinc-67

We wish to report the observation of nuclear resonance absorption (Mössbauer effect[1]) of the 93 keV., 9·4 μsec. γ-ray[2] of zinc-67. The energy width of this line is $4{\cdot}84 \times 10^{-11}$ eV., and the fractional energy resolution, defined as the ratio of twice the natural line width to the γ-ray energy, is 1 part in 10^{15}, and is 10^3 fold narrower than that reported[3] for iron-57. By the same token, the resonance is difficult to observe, because it is easily destroyed by small-amplitude sound vibrations and broadened and weakened by nuclear electric quadruple interactions in the crystals[4].

A search for the resonance was made using a mechanically rigid package of absorber and source, suspended by threads inside a liquid-helium cryostat. The resonance condition was destroyed by applying an external magnetic field to the absorber but not the source, making use of the nuclear Zeeman effect.

A source of 78-hr. gallium-67 was prepared by deuteron bombardment of a ceramic zinc oxide slab. Gallium-67 decays by electron capture to excited states of zinc-67. Following annealing of the source in a helium atmosphere for 18 hr. at 366° C., the source and a ceramic zinc oxide absorber (thickness 5·6 gm./cm.^{2}) were placed in a shock-mounted helium cryostat. A solenoid surrounding the absorber provided a magnetic field. The source was mounted at a distance of 1·5 cm. from the absorber, and was shielded from the magnetic field by a superconducting lead foil. The experiments were performed at temperatures below the helium λ point, thereby eliminating boiling and assuring equality of source and absorber temperatures. Freezing the nitrogen radiation shield prevented vibrations due to boiling liquid.

Determinations were made of the increase in transmission of the 93-keV. gamma radiation through the zinc oxide absorber on application of a magnetic field to the absorber. A field of 150 oersted is expected to destroy the resonance condition completely, assuming no line broadening. With an applied field of 500 oersted the low-temperature transmission was found to increase by (0·080 ± 0·008) per cent over the zero field value. After correction for background in the γ-ray spectrum the transmission increase is (0·240 ± 0·025) per cent.

Control experiments were run at room temperature, where no resonance is expected, using the 93-keV.

γ-ray, and at low temperatures using a 184-keV. non-resonant γ-ray. An unannealed zinc oxide absorber was studied. Measurements were taken on annealed (14 hr. at 650° C.) and unannealed zinc spinel (zinc oxide–alumina). Because of difficulty in placing the active gallium atoms in the proper lattice positions in the spinel, no resonance was expected, and none was observed. The results of all our measurements are summarized in Table 1. The magnetic fields used were in all cases approximately 500 oersted. The only significantly non-zero resonance is found in the annealed zinc oxide at low temperatures.

Table 1

Material	Annealed	γ-Energy	Temperature (° K.)	Resonance (per cent)
ZnO	yes	93 keV.	<2·17	0·080 ±0·008
ZnO	no	93	<2·17	−0·06 ±0·06
ZnO	yes	93	300	0·005 ±0·003
ZnO	yes	184	<2·17	0·02 ±0·02
Spinel	yes	93	<2·17	0·016 ±0·014
Spinel	yes	93	300	0·02 ±0·03

Despite the minute resonance strength observed in zinc oxide, the ratio of the resonance strength to the energy resolution is larger than for any other resonance thus far reported (about three times larger than has been obtained with the 14-keV. line in iron-57[3]), and hence the 93-keV. γ-ray of zinc-67 provides the possibility for the most precise nuclear clock available. We are at present attempting to enhance the observable resonance through the utilization of resonant scattering methods, and are studying the isotope shift expected when the isotopic constitutions of source and absorber are different.

We wish to express our thanks to Stephen Stoddard and Robert Cowan for preparing the zinc oxide samples, to Donald R. F. Cochran for help with irradiations, and to J. G. Dash for a number of helpful discussions.

This work was performed under the auspices of the U.S. Atomic Energy Commission.

D. E. Nagle
P. P. Craig
W. E. Keller

University of California,
Los Alamos Scientific Laboratory,
Los Alamos, New Mexico.

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Mass of Elementary Particles

Prof. A. J. Rutgers in *Nature* of September 19, 1959, and Dr. R. L. Worrall in *Nature* of February 27, 1960, pointed out that the ratio of proton to electron mass could be calculated from simple functions. It appears that the masses of most elementary particles can be calculated, approximately, using three quantities, h, Planck's constant, a, the fine structure constant, and e, the base of the natural logarithms. The calculated values obtained are in good agreement with the known values.

Worrall suggests the following equation for calculating the mass of the proton:

$$M_p = \text{mass proton} = (10^4/2e)\ M_e$$

where M_e is the mass of the electron. Since $e^2 \sim 10^3 a$, it is possible that the fine structure constant is involved. $M_p \sim (5e/a)\ M_e$.

Meson masses can be calculated in the following way:

Mu meson : $1/e\ (4/a)\ M_e$	$\sim$	$202\ M_e$
π meson : $(2/a)\ M_e$	$\sim$	$274\ M_e$
K meson : $(7/a)\ M_e$	$\sim$	$959\ M_e$
Hyperon : $(7/5)\ M_p$	$\sim$	$2{,}585\ M_e$

The observed masses are almost exactly equal to the calculated masses.

The hyperons may have the following structure:

$1{,}840 + 959/e + 959/e$	$\sim$	$2{,}545\ M_e$
$1{,}840 + 959/e + 274/e$	$\sim$	$2{,}295\ M_e$
$1{,}840 + 959/e$	$\sim$	$2{,}190\ M_e$

Since a binding energy may also be present, these calculated values are not unreasonable. However, if they are correct the factor e appears to be important. There is a mass decrease on particle formation through action of the factor $1/e$ as suggested by Worrall. However, the factor could be $1/(10^3 a)^{1/2}$.

The electron mass can be expressed in terms of frequency and c^2 by the equation:

$$h/M_e = c^2/v \sim 7{\cdot}3 \text{ cm.}^3/\text{sec.}$$
$$7{\cdot}3 \sim 10^3 a \sim e^2$$
$$h/e^2 \sim 9 \times 10^{-23}$$

There are now three nearly equal quantities involved in mass calculations. Meson masses can be expressed as follows:

$$\text{Mass of mu meson} = (1/e)\ 4\ h/a\ (c^2/v)$$

It seems reasonable to suppose there is some connexion between the three quantities in the above equation. The ultimate equation may involve only h/c^2, a conversion factor dependent on the units used, and an energy-level factor.

In view of the importance of the problem, the above relationships perhaps deserve consideration.

S. C. Horning

200 E. Rose Valley Road,
Wallingford, Pa.

BIOPHYSICS

Flow of Blood through Narrow Tubes

In a recent communication, Haynes[1] describes experiments on the flow through capillary tubes of suspensions of erythrocytes in standard acid–citrate–dextrose and proposes an equation relating volume flow in unit time to applied pressure. He also refers to my use of Casson's equation[2] for somewhat similar results obtained by various authors on blood (treated with coagulants) from a number of species[3,4]. Although Haynes's comments are entirely correct so far as they go, it seems that the matter requires further clarification.

The essential point is that, to further our understanding of the sigma phenomenon in full blood, it is greatly advantageous to be able to describe the flow-curves over a wide experimental range of shear-rate by means of two parameters the variation of which with capillary radius can then be quantitatively studied. Such studies would be less interesting for suspensions of erythrocytes alone than for full blood, except that Dr. Haynes evidently finds (private com-

munication) no difference in the shapes of the pressure-flow curves.

From the form of Casson's equation, it is clear that it cannot express a fundamental law of flow. For example, a reversal of the direction of stress would introduce imaginary quantities; but the straight lines obtained when the square root of shear-rate is plotted against the square root of stress (both at the capillary wall) serve our purpose, since any straight line is definable by its slope and its intercept on extrapolation to some axis. By 'yield-value' is meant only the extrapolated intercept of these straight lines extended to the stress axis.

In a second communication, Reiner and Scott Blair[4] calculated the curvature which would take place if the same equation were to hold for any system down to an experimentally determinable yield-value. We would certainly not have wished to imply that blood has a yield-value in this sense, since none of the published results appeared, at the time, to cover a low enough range of shear-rates to decide the point.

Since these communications were published, more systems have been found to follow Casson's equation (see Heinz[5]), and the extension proposed by us for low shear-rates may well be applicable to some of them.

I am indebted to Dr. R. H. Haynes for his kindness in elucidating a number of points in private correspondence.

G. W. Scott Blair

National Institute for Research in Dairying,
University of Reading.
March 22.

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METALLURGY

Optical Properties of Bismuth

As part of a programme to investigate applications of the polarizing microscope to metallography, a study has been made using bismuth single crystals. The single crystals were prepared from material of a purity not less than 99·99 per cent bismuth, by controlled solidification from a capillary tube. As a check on purity, X-ray measurement of the unit cell dimensions gave values of $a = 4{\cdot}5366$ kX., $c = 11{\cdot}8402$ kX., indexed on a hexagonal basis. Sections of the various crystals were machined flat and electropolished[1]. The orientation of each crystal was determined using the polarizing microscope, a few of the orientations being checked by X-ray back reflexion[2].

The directions of complete extinction (uniradial directions) of each section were set at 45° to the plane of vibration of the polarizer and the rotation of the analyser found which produced extinction in monochromatic light. After rotation of the crystal on the stage by 90° another measurement of the analyser rotation in the opposite sense was obtained. The difference between these two measurements gave twice the analyser rotation angle.

Fig. 1 shows the experimental results, using yellow light (5890 Å.) with $2A$, twice the angle of analyser rotation, plotted against the angle α between the optic axis and the normal to the plane of section. The broken line represents the best curve through the experimental points while the solid curve gives the true rotations after making correction for the rotation due to the reflector slip of the microscope. Rotations due to phase differences are included in the rotation angles shown in Fig. 1. These rotations are small and within experimental error, the maximum phase difference at this wave-length being 1·1°. Measurements of phase difference and their effects are shown in Table 1, the figures in the columns headed L being obtained with an elliptic compensator in the tube slot of the microscope.

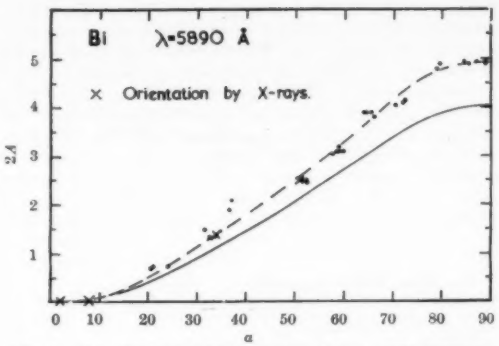

Fig. 1. $2A$, Analyser rotation angle × 2; α, angle between basal plane and plane of section; – – – –, experimental curve; ———, experimental curve corrected for reflector rotation

The reflectivities in the two uniradial directions of a crystal with $\alpha = 87°$ were measured using a Cooke, Troughton and Simms visual microphotometer (Berek type) with a basal section of quartz as a standard. The reflectivities at three wave-lengths and their ratios are given in Table 1, together with

Table 1. Bismuth Single Crystal. Sign of Rotation Negative. Optic Axis [111] inclined 3° to Section Surface. $\alpha = 87°$

Wave-length (Å.)	4860		5890		6560	
Microscopy		*L**		*L*		*L*
$2A$, analyser rotation angle × 2	−4·93	−5·23	−4·95	−5·1	−4·35	−4·5
Angle $2A$ corrected for reflector rotation	−4·02	−4·26	−4·04	−4·16	−3·54	−3·67
Phase difference ($\triangle e - \triangle o$)		−2·79°		−1·09°		−1·09°
Reflectivity ratio (intensities) Re^2/Ro^2	0·869	0·863	0·869	0·865	0·884	0·880
Photometry Re^2, reflectivity of vibrations in axial plane	56·3%		63·1%		67·1%	
Ro^2, reflectivity of vibrations in basal plane	64·9%		72·6%		75·4%	
Reflectivity ratio (intensities) Re^2/Ro^2	0·868		0·870		0·890	

Refractive indices measured at wave-length 4361 Å. (A. P. Lenham)
Optic axis $n'_e = 1{\cdot}20$–$2{\cdot}47i$
Basal plane $n'_o = 0{\cdot}89$–$2{\cdot}58i$

Calculated values

Reflectivity Re^2	Reflectivity Ro^2	Reflectivity ratio Re^2/Ro^2	Phase difference ($\triangle e - \triangle o$)
56·1 %	65·1%	0·861	−1·6°

* *L*, Elliptic compensator used to measure phase difference.

ratios calculated from analyser rotations. The ratio of reflectivities calculated from values of the optical constants (Lenham, A. P., private communication) for the same crystal, is included for comparison.

Measurement of the analyser rotation angle thus provides a rapid method of determining the tilt of the optic axis ([0001] on hexagonal indexing, [111] on both rhombohedral descriptions). The accuracy is probably limited to about $\pm 5°$ with standard equipment, but the method can be used with polycrystalline samples even if the grain size is small.

H. D. Mallon
I. G. Runciman

Metallurgy Branch,
Royal Military College of Science,
Shrivenham.

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Effect of Moisture on Carboxylic Acid Adsorption to Steel

Qualitative evidence has been given[1] that oils compounded with efficient dicarboxylic (alkylated succinic acids) rust inhibitors will not prevent rusting at certain low concentrations of the additive. When oil at these low concentrations of inhibitor was saturated with water, however, rust protection was obtained. Von Fuchs attributed this behaviour to the chemical reaction of iron with water to form ferrous hydroxide, which in turn can react with the acidic inhibitor to form a tenacious film of soap on the metal surface. Another investigation[2], using stearic acid labelled with carbon-14, demonstrated that the acid is adsorbed more readily to ferrous surfaces from hydrocarbon solution containing entrained moisture than from a relatively dry solution. This phenomenon of enhanced adsorption to the metal surface was explained by Ries *et al.* as probably being due to an increase in the oxide coating produced by the presence of moisture.

In this work it was discovered that the adsorption could be enhanced not only by moisture in the oil, but also by an invisible layer of moisture adsorbed on the metal surface prior to application of the oil. This suggested a means of determining the mechanism of the water catalysis, since if the phenomenon is due to an increase in oxide surface, the effect would be observed on a surface originally treated with moisture even if it were dried thoroughly before applying the inhibited oil.

To determine the relative amounts of carboxylic acid adsorbed from an oil solution on to the back surface of a polished steel planchet, an alkylated succinic acid labelled with carbon-14 was used. Three drops of a 0·015 per cent solution of the acid in mineral oil were deposited on a planchet surface. After 2 min. of contact at room temperature, the oil was blotted off thoroughly with filter paper and the radioactivity remaining on the planchet determined. This residual activity is equal to the activity adsorbed to the surface plus the activity remaining in the thin film of oil not removable by blotting. Any increase in this total residual activity resulting from variations in preparation of the metal surface must be due, of course, to increased adsorption of the radioactive species to the surface. Treatment of the polished planchets before depositing the radioactive oil consisted of exposure to a column of steam for varying periods of time ranging from 30 sec. to 4 min. After this exposure, the visible layer of condensed steam was allowed to evaporate, leaving behind the invisible film of adsorbed moisture. Half the metal samples thus obtained were immediately treated with inhibited oil. The other half were dried in an oven at 120° C. for 3 days to remove the invisible adsorbed film of moisture, before application of the oil. The results of the experiments are given in Table 1.

Table 1. Effect of Moisture on Adsorption of an Alkylated Succinic Acid on to Smooth Steel Surfaces

Sample No.	Exposure to steam (sec.)	Resulting condition of surface	Heat drying treatment after steam exposure	Residual activity after blotting off oil (counts/min.)
1	0			438
2	0			464
3	30	no visible rust	none	824
4	30	no visible rust	120° C. for 3 days	372
5	30	no visible rust	120° C. for 3 days	398
6	60	incipient rusting	none	1,155
7	60	incipient rusting	none	1,451
8	60	incipient rusting	120° C. for 3 days	534
9	60	incipient rusting	120° C. for 3 days	464
10	240	heavy rusting	none	1,833
11	240	heavy rusting	120° C. for 3 days	568

It can be seen that even if the surface oxide area of a steel specimen is enormously increased through exposure to moisture, there is little increase in absorption if the surface is dried thoroughly before applying the oil. On the other hand, surfaces exposed to moisture under conditions resulting in very little increase in the surface oxide area will undergo a tremendous increase in adsorptive capacity for carboxylic acids if the adsorbed layer of water molecules is not removed before treatment with the acid. The effect of water in increasing the adsorption of carboxylic acids from oil solution on to iron surfaces is consequently not due primarily to an increase in the surface oxide area of the metal, but rather to direct participation of the water at the time of the adsorption reaction.

The opinions or assertions contained in this communication are our own and are not to be construed as official or reflecting the views of the Naval Service at large.

M. E. Schrader
J. L. Kalinsky

Material Laboratory,
New York Naval Shipyard,
Brooklyn 1, New York.

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RADIATION CHEMISTRY

Chemical Effects of Ionizing Radiation on Deoxyribonucleic Acid in Dilute Aqueous Solution

When purine and pyrimidine nucleotides in dilute aqueous solution are irradiated with ionizing radiation they are destroyed by two pathways[1]. The minor pathway is attack upon the sugar moiety followed by release of free base[1]. Details of the mode of sugar attack have not been established; but possible reactions have been suggested by Daniels *et al.*[2]. The

major pathway is attack of the base moiety which with purines in the absence of oxygen yields the corresponding formamido-pyrimidine nucleotide[3]. When pyrimidine nucleotides are irradiated in the absence of oxygen sugar phosphate is liberated, but there is no ultra-violet absorbing product arising from base attack. When oxygen is present during irradiation G-values (molecules per 100 eV.) for nucleotide destruction are increased 2–3 times[4]. For purine nucleotides the increased degradation in oxygen is almost entirely an augmented base attack, but no ultra-violet product arising from it is found[4]. When pyrimidines are irradiated in the presence of oxygen hydroxy-hydroperoxides are formed[5]. G-values for destruction of pyrimidines in the presence of oxygen are greater than those for purines[1,6] and suggest that when deoxyribonucleic acid is irradiated pyrimidines will be destroyed to a greater extent. Extrapolation of the effects of radiation upon nucleotides to effects upon deoxyribonucleic acid is complicated in an uncertain way by the influence of internucleotide linkages and hydrogen bonding of base pairs. This communication reports the amounts of base and sugar destroyed when aqueous solutions of calf thymus deoxyribonucleic acid are irradiated.

To determine whether radiochemical changes varied with different samples of deoxyribonucleic acid the chemical changes were compared after irradiating samples of calf thymus deoxyribonucleic acid from four separate preparations. Solutions of approximately 5 mgm. acid/ml. were prepared with triple-distilled water and neutral phosphate buffer added (final concentration 10^{-2} M). Air bubbles were removed by cautious evacuation, but solutions were irradiated under air. Solutions were irradiated with 15-MeV. electrons to a dose of 10^6 rads. It is assumed that the initial 7×10^5 rads use up all dissolved oxygen[1] and since the dose is delivered within 90 sec. the remaining 93 per cent of the dose is delivered to an oxygen-free solution. Samples of control and irradiated solutions were hydrolysed in hot perchloric acid and their base compositions determined by paper chromatography[7]. The total base change was 10 per cent of the control. G-values for bases changed were calculated and are given in Fig. 1. There is little variation between samples of deoxyribonucleic acid, and thymine is destroyed to the greatest extent. Perchloric acid hydrolysis gives a low value of thymine[7], and it seemed possible that as irradiated material is degraded the yield of thymine may be further lowered, giving an artificially high value for G(–thymine). However, when the hydrolysis was repeated with formic acid at 175° C., which does not give a low value for thymine[7], G-values were essentially the same as obtained after perchloric acid hydrolysis. When samples of irradiated deoxyribonucleic acid are run on paper in an n-propanol–water solvent[8] all phosphates remain at the origin and free bases can be isolated. Adenine, guanine, cytosine and thymine were isolated when 1-ml. samples of irradiated deoxyribonucleic acid were run on paper, and their yields were determined from the ultra-violet absorption of their eluates (Fig. 2). Amounts of base released, that is, sugar attacked, are approximately one-quarter of the amounts of base destroyed. G-values for adenine and cytosine released are slightly higher than those for guanine and thymine. It is not readily possible to determine amounts of free base, if any, present in the control solution. If any free base is present it will only strengthen the conclusion that base attack is the major reaction.

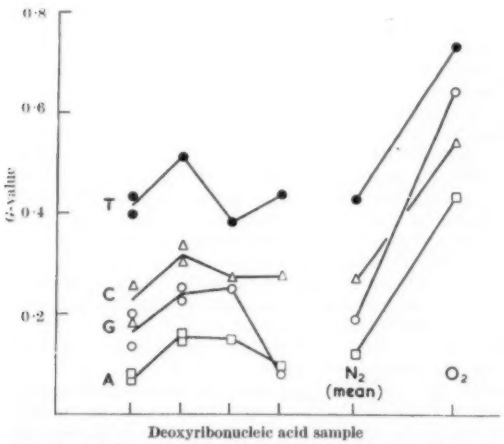

Fig. 1. G-values for bases destroyed when aqueous solutions of calf thymus deoxyribonucleic acid (5 mgm./ml.) are irradiated with 15-MeV. electrons. □, Adenine; ○, guanine; △, cytosine; ●, thymine

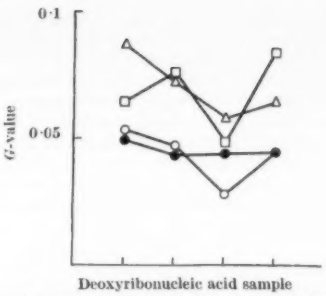

Fig. 2. G-values for bases released when aqueous solutions of calf thymus deoxyribonucleic acid are irradiated with 15-MeV. electrons in the absence of oxygen. □, Adenine; ○, guanine; △, cytosine; ●, thymine

In addition to free bases, 2 : 4-diamino-5-formamido-6-hydroxypyrimidine is found in irradiated deoxyribonucleic acid and arises from attack on the guanine moiety[3]. Amounts of 2 : 4-diamino-5-formamido-6-hydroxypyrimidine are smaller than G(–guanine), but are increased by warming the irradiated deoxyribonucleic acid solution, at pH 7 and 80° C., for 1 hr. It is assumed that attack upon guanine yields 2 : 4-diamino-5-formamido-6-hydroxypyrimidine attached to the sugar by a labilized glycosidic linkage. Attack on adenine forms the corresponding formamido-pyrimidine[4], but none could be found in the irradiated deoxyribonucleic acid. However, amounts of adenine changed are small and the formamido-pyrimidine could easily escape detection.

A solution of deoxyribonucleic acid, concentration 2 mgm./ml., was irradiated to $1{\cdot}7 \times 10^5$ rads, the solution being kept saturated with oxygen during irradiation. Control and irradiated solutions were hydrolysed in perchloric acid and the base composition determined (Fig. 1). While the total amount of base destroyed is 2·5 times greater in the presence of oxygen, the relative amounts of each base destroyed are approximately the same as when oxygen is absent. The G-value for adenine released in the presence of oxygen is 0·06, which is close to the value in the absence of oxygen. This is consistent with the finding

with purine nucleotides that enhancement by oxygen is an increased attack upon the base moiety.

When tissue is irradiated, it is likely that the effects of the indirect action will be the same as *in vitro*. Assuming *G*-values for an aqueous solution, irradiation of tissue to a dose of 10^3 rads will change one base in 10^4. If it is assumed that cell constituents, adjacent to nucleic acid, compete 10 times (or 100 times) more efficiently than deoxyribonucleic acid for radicals there will be one nucleotide changed in 10^5 (or 10^6) per 10^3 rads. Damage of this extent would be expected to interfere severely with the function of the cell. The changes produced in the absence of oxygen will be removal of pyrimidines and conversion of purines to formamido-pyrimidines. Since the latter have labile sugar-linkages the ultimate result may be removal of purines. For every four bases removed one sugar will be attacked and presumably the sugar–phosphate backbone will be broken. Oxygen, present during irradiation, will increase the amount of base destroyed by a factor of 2·5, but sugar breakage will be little changed. Thus the indirect action of ionizing radiation upon the bases of deoxyribonucleic acid seems to be adequate to account for observed biological damage and for the increase in damage of approximately 2·5 times in oxygen, observed for a wide array of biological changes[8].

The action of alkylating agents on deoxyribonucleic acid sheds further light on the chemical changes in deoxyribonucleic acid which may be important biologically. P. Brookes and P. D. Lawley (personal communication) have shown that when deoxyribonucleic acid is treated with low doses of an alkylating agent, guanine is alkylated to a much greater extent than the other three bases. Alkylation of the guanine moiety labilizes the glycosidic link, which is slowly hydrolysed.

It is interesting to speculate that biological changes brought about by alkylating agents and ionizing radiation are associated with removal of guanine from deoxyribonucleic acid. Further, radiobiological changes not produced by alkylating agents may be associated primarily with removal of thymine.

I am indebted to Prof. J. A. V. Butler, who so kindly supplied samples of calf thymus deoxyribonucleic acid, and gratefully acknowledge financial support by the William Shepherd Fellowship. This investigation has been supported by grants to the Chester Beatty Research Institute (Institute of Cancer Research : Royal Cancer Hospital) from the Medical Research Council, the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund, and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service.

G. Hems

Chester Beatty Research Institute,
Institute of Cancer Research,
Royal Cancer Hospital,
Fulham Road, London, S.W.3.

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CHEMISTRY

The Tesla-coil Method for producing Free Radicals from Solids

Most of the methods in current use for producing radicals from crystalline solids for study by electron spin resonance involve the use of high-energy radiation and therefore require comparatively expensive and elaborate equipment. Papazian[1,2] showed that several substances, including hydrazoic acid and methyl iodide, condensed from the vapours at liquid-nitrogen temperature developed colour when sparked with a Tesla-coil ; this was attributed to free-radical formation. Using the electron spin resonance technique we have found that radical concentrations as high as 10^{18}/gm. (approximately 10^{-3} mole $l.^{-1}$) can be obtained by applying the discharge from an ordinary vacuum leak-tester to finely ground crystals of many organic substances contained in partially evacuated electron spin resonance specimen tubes. For low-melting solids, for example some vinyl monomers, the following procedure is sometimes convenient. The degassed liquid is frozen in a thin layer on the walls of the evacuated tube, which is then cooled to − 195° C. and vibrated vigorously. The crystals are thus detached from the walls and deposited in a fine powder at the bottom of the tube. A suitable gas at a pressure of about 0·1 mm. mercury is admitted and the probe of the Tesla-coil applied in the neighbourhood of the crystals, the tube being maintained at a low temperature and preferably vibrating. With high-melting solids it suffices to grind the crystals finely in a mortar before introduction into the specimen tube. Nitrogen, hydrogen, argon and oxygen have been used, in order of decreasing effectiveness. The presence of a gas is desirable but not absolutely essential. The spectrum obtained is independent of the nature of the gas. Radical concentrations of the order of 10^{-4} mole $l.^{-1}$ are often produced in a few seconds by this technique. Substances examined include glycine, diketopiperazine, acrylamide, potassium and lithium methacrylates, acrylic, methacrylic, *n*-butyric and itaconic acids, acrylonitrile and polyacrylonitrile, all of which gave strong radical spectra. Surprisingly, a negative result was obtained with azo-*bis*-*iso*butyronitrile. The radicals from these compounds show widely differing thermal stabilities and reactivities towards oxygen.

Methacrylic acid was selected for further study. The spectra obtained were identical to those produced by γ-irradiation of methacrylate polymers[3]. The limiting radical concentration which could be obtained with prolonged excitation by the Tesla-coil at about − 195° C. was approximately 10^{-3} mole $l.^{-1}$. It is interesting that this value is within an order of magnitude of the number of radicals in a unimolecular layer on the surface of the crystals (estimated from simple microscopic examination of the crystal size), and we believe that the radicals formed with excitation by the Tesla-coil reside mainly on the surface initially. In agreement with this it was found that at − 78° C. the radicals react with oxygen to form new radicals with an asymmetric spectrum of the type given by $RO\dot{O}$· (ref. 4) in a time too short to permit observation with the present apparatus, that is to say, within 30 sec. On the other hand, the reaction with nitric oxide at a pressure of 17 mm. mercury at the same temperature is comparatively slow, with a half-life of about 1 hr.

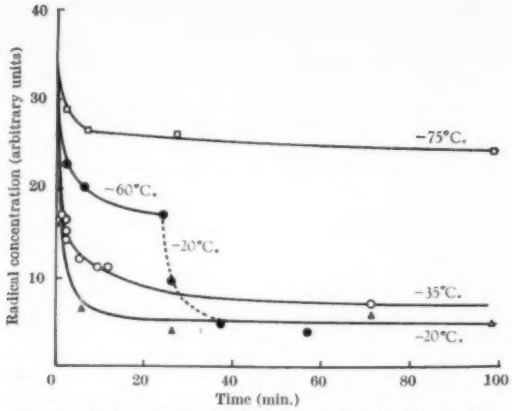

Fig. 1. Decay of surface radicals on methacrylic acid crystals at various temperatures. Scale of radical concentration is arbitrary, but 30 units = 10^{-2} mole $l.^{-1}$, approximately. Different symbols are used to distinguish between different experiments

On warming a specimen containing the initial radicals to 0° C. for 5 min. the radical concentration decays to the limit of detectability (10^{-6} mole $l.^{-1}$ approximately). The effects of warming to various temperatures between −195° C. and 0° C. are shown in Fig. 1. The abscissa represents the total time at the appropriate temperature; spectra were always taken with the specimen at −195° C. At each temperature there is an initial comparatively rapid decay to an almost stationary value, and is found to be inversely proportional to the temperature.

The dotted curve shows the result of an experiment at two temperatures. After excitation by the Tesla-coil, the tube was warmed for 24 min. to −60° C. to achieve the stationary concentration at this temperature, and then warmed to −20° C. for successive short periods. This treatment resulted in a decay in radical concentration to the stationary value for −20° C.

These results are understandable if the radicals on the surface of the crystals are immobile at −195° C. but became progressively mobilized as the temperature is raised. Such would be the case if the energies binding the radicals to the surface were distributed over a wide spectrum. Possibly the radicals are not entirely monomeric; the mobility would then depend on the degree of polymerization.

With repeated excitation by the Tesla-coil at −195° C. and warming to 13° C. a high radical concentration (10^{-3} mole $l.^{-1}$) may be built up. These radicals are stable at 13° C., but react rapidly with oxygen. It would appear that a surface polymerization had occurred in this experiment, producing large immobile radicals. In a similar experiment with *n*-butyric acid no such effects were observed.

These experiments illustrate some of the possible uses of this simple technique, which may have applications not only in the study of free radicals, but also in the investigation of surface reactions.

C. H. Bamford
A. D. Jenkins
J. C. Ward

Research Laboratory, Courtaulds, Ltd.,
Maidenhead, Berks.

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Polymerization of Crystalline Methacrylic Acid initiated by Ultra-violet Radiation

In recent years it has been shown that a number of crystalline vinyl monomers polymerize when irradiated by γ-rays[1-4] or high-energy electrons[5]. However, there appears to be no report in the literature of the ultra-violet initiation of solid-state polymerization, although this process could, in principle, facilitate elucidation of the mechanism of the reaction.

We have found that crystalline methacrylic acid (m.p. 16° C.) may be polymerized by radiation from a high-pressure mercury arc using a quartz optical system, or with azo-*bis*-*iso*butyronitrile as photosensitizer using a 'Pyrex' glass system. In these experiments the crystals had a water content of approximately 0·01 per cent w/w; the presence of some water appears necessary for polymerization, at least in the sensitized reaction. In this latter case the rate falls off after a comparatively small conversion which increases with the concentrations both of the sensitizer and water at 13° C. On the other hand, the unsensitized reaction is autocatalytic in the early stages and may ultimately lead to complete conversion.

The rate in the early stages of the sensitized reaction is proportional to the first power of the light intensity and of the concentration of sensitizer. Measurements of the kinetic chain-length made using sensitizer labelled with carbon-14 ($4{\cdot}3 \times 10^{-3}$ mole $l.^{-1}$) give values of approximately 700 in the early part of the reaction, substantially independent of the light intensity. This corresponds to a rate of chain starting of $5{\cdot}0 \times 10^{-7}$ mole $l.^{-1}$ $sec.^{-1}$ under our standard 'high-intensity' conditions, and a rate of polymerization of $3{\cdot}5 \times 10^{-4}$ mole $l.^{-1}$ $sec.^{-1}$. Under the same conditions the decomposition of the sensitizer was followed by observing the nitrogen evolution, and thus the efficiency of initiation was estimated. It turns out to be approximately 0·5, that is, not very different from that found in liquid-phase polymerizations.

After irradiation radicals can be detected in the frozen mass by electron spin resonance. Their concentration increases with the period of irradiation, and also strongly with the sensitizer concentration. In the range of sensitizer concentrations studied (up to $1{\cdot}3 \times 10^{-2}$ $ml.^{-1}$) only a small fraction of the total radicals produced by the light—approximately 10 per cent—become permanently trapped. These radicals are stable for long periods at 0° or 13° C., no detectable change occurring during 17 hr. at 0° C. The permanently trapped radicals are apparently located in sites unsuitable for further propagation, since no after-effect could be detected even in periods up to 17 hr. at 13° C. The spectrum of the radicals is the same as that observed in γ-irradiated methacrylate polymers by Abraham, Melville, Ovenall and Whiffen[6]. On admission of oxygen the spectrum changes to the asymmetric type shown by *R*OO· radicals[7].

When irradiation is carried out in the presence of oxygen which is admitted to the system after crystallization is complete the polymerization proceeds normally. Since the liquid-phase photopolymerization is strongly inhibited by oxygen the propagating radicals in the solid must be inaccessible to oxygen. On the other hand, the permanently trapped radicals appear to be situated on the surface of the solid.

The degrees of polymerization of the polymers, determined viscometrically, varied in a rather erratic manner, but were generally around 4,000, independent of the rate of initiation. Since this value is considerably greater than the kinetic chain-length, the polymers must be markedly heterodisperse, perhaps owing to the fact that the sensitizer in these experiments was not uniformly distributed throughout the specimens. The crystals were prepared by freezing solutions of the sensitizer in the liquid monomer, and it was shown by ultra-violet absorption measurements that the first crystals to separate contained a relatively low concentration of sensitizer.

The above experiments do not establish that propagation through the crystal lattice occurs. The actual locus of polymerization is being determined by irradiating both large single crystals and thin crystal layers coupled with microscopic observation. Preliminary results indicate that the polymerization is at least partly a phase-boundary reaction.

C. H. Bamford
A. D. Jenkins
J. C. Ward

Research Laboratory, Courtaulds, Ltd.,
Maidenhead, Berks.

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A Monte Carlo Equation of State for Mixtures of Hard-Sphere Molecules

Progress in the theory of mixtures is limited by the lack of adequate approximate solutions of the classical many-body problem. Thus at densities greater than those appropriate to the virial expansion no satisfactory estimate of the properties of mixtures is possible. However, the Monte Carlo method enables the evaluation of the many-dimensional configurational integral to be performed by a sampling procedure. The method is applicable to any form of intermolecular potential.

The preliminary investigations of the properties of mixtures were made on mixtures containing two types of hard-sphere molecules with a ratio of diameters $\sigma_\beta/\sigma_\alpha = 1{\cdot}667$. Systems of 32 and 64 molecules were studied, the molecules being confined in a cubic space by means of periodic boundary conditions[1-3]. Initially the two species of molecules were distributed randomly on a face-centred or simple cubic lattice. New configurations were generated by moving one particle at a time, and the results analysed in terms of three cumulative distribution functions, corresponding to the three types of molecular interaction in the mixture. A check of the method, using 'mixtures' of molecules of equal size, showed internal consistency among the distribution functions and good agreement with the results for single-component systems obtained by Wood and Jacobson[4] and Alder and Wainwright[5]. In the case of mixtures the validity of the method was examined by comparing the results obtained from systems with different numbers of molecules and with differing distributions of the two species on the initial lattice. The agreement is illustrated by the following values of pV/RT for an equimolar mixture at a reduced density, $1/V^*$, of 0·5: 32 molecules, 2·95; 32 molecules, initial distributions interchanged, 3·07; 64 molecules, 3·01;

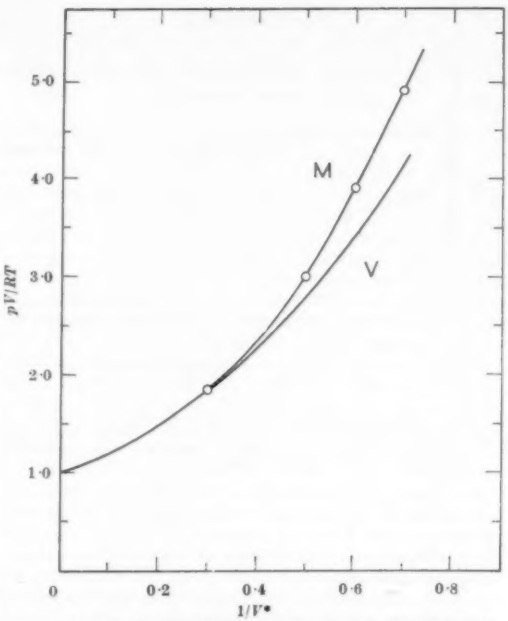

Fig. 1. pV/RT as a function of $1/V^*$ for an equimolar mixture of hard spheres for which $\sigma_\beta/\sigma_\alpha = 1{\cdot}667$. The lower line ($V$) represents the results of the virial expansion and the upper line (M) is that obtained from the Monte Carlo calculations

$$\frac{1}{V^*} \text{ is defined as } \frac{N_\alpha \sigma_\alpha^3 + N_\beta \sigma_\beta^3}{V}$$

where N_α is the number of molecules of type α and σ_α is their diameter. V is the volume of the system.

Fig. 1 shows the equation of state for molecules of the given size ratio in an equimolar mixture over a range of density. The lower curve represents the results obtained from the virial expansion[6], which are consistent with the Monte Carlo results at lower densities but deviate markedly at higher densities.

A full investigation is now being undertaken to determine the effect of different size ratios and to examine the thermodynamic properties of mixtures of varying composition.

The calculations were performed on the Ferranti Mercury computer at the Computing Laboratory, University of Oxford. Considerable computing time has been required, and we wish to thank Miss S. A. Tilley for her interest and assistance.

E. B. Smith
K. R. Lea

Physical Chemistry Laboratory,
Clarendon Laboratory,
University of Oxford. April 12.

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Spectroscopic Applications of Photographic Emulsion Mosaics

A COMPREHENSIVE spectral survey over as wide a wave-length range as possible is a frequent early requirement during spectroscopic studies of terrestrial and astronomical light sources. Such surveys are often made with low-dispersion prism spectrographs, and sometimes with grating instruments.

The availability of Kodak *O* to *Z* emulsions[1] (and similar emulsions of other manufacturers, for example Ilford *Q* emulsions), each sensitized to have a maximum response in a different wave-length region, enables a spectroscopic survey to be made by a sequence of separate exposures of different emulsions, each selected on the basis of wave-length range of maximum sensitivity. In cases where only one exposure is possible or practicable (for example, to transient and/or very feeble light sources) one specific emulsion (for example, 1–*N* or 103 *aF*) is often used as the most acceptable compromise for high sensitivity over as wide a wave-length range as possible. The inherent variations in the sensitivity of a single emulsion over the wide wave-length range often give rise to non-uniformly exposed plates.

The availability of the Kodak emulsions on films, however, makes it possible to assemble mosaics made up of two or more segments of different emulsions, each easily cut to a length specific to the wave-length range of its maximum sensitivity. For example, the "Kodak Data" book[1] specifications of relative emulsion sensitivity (defined therein as the reciprocal of the exposure to tungsten radiation in metre candles seconds which will produce a density of 0·6 above gross fog when the material is developed for the recommended time in Kodak developer *D*–19) show that a mosaic of optimum sensitivity to 9000 Å. may be assembled by using type *O* emulsion to 5000 Å., type *F* emulsion between 5000 Å. and 7000 Å., and type *N* emulsion between 7000 Å. and 9000 Å. In addition, the range of optimum sensitivity can be extended, if required, to 12,000 Å. by using hypersensitized *M* emulsion between 9000 Å. and 9800 Å., hypersensitized *Q* emulsion between 9800 Å. and 10,200 Å., and hypersensitized *Z* emulsion between 10,200 Å. and 12,000 Å.

The gain in sensitivity obtained by the use of an optimum emulsion mosaic in place of a single emulsion is illustrated in Fig. 1, compiled from individual sensitivity curves given in the "Kodak Data" book. An emulsion mosaic assembled in the manner specified above is a detector the sensitivity of which as a function of wave-length is an envelope of the individual curves of Fig. 1. The response of *O* emulsions is not given in the "Kodak Data" book below 4000 Å., but, as is well known, *O* emulsions perform adequately between 2000 Å. and 5000 Å. The mosaic sensitivity can be extended to shorter wave-lengths by use of Ilford *Q* emulsions or other Schumann type emulsions.

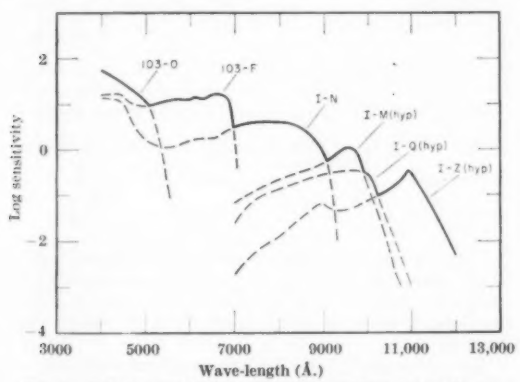

Fig. 1. Relative sensitivity of Kodak emulsions and optimum sensitivity of emulsion mosaic (solid curve)

The practicability of using emulsion mosaics has been tested by using segments of 103–*aO*, 103–*aF*, and 1–*N* 16 mm. film in conjunction with Hilger medium quartz and medium glass spectrographs. A flexible rectangular brass plate (10 in. × 4 in.), to which brass guides were attached to hold the film segments, was used in the spectrograph plate holder in place of the usual glass plate. Each segment of film, of a length appropriate to its wave-length range of maximum response, was cut with slightly oblique ends, which matched those of its neighbours. In this way no spectral features were lost at the boundaries between segments. The mosaic, and separate strips of *O*, *N*, and *F* film equal in length to the mosaic, were exposed for equal times to a microwave discharge through carbon dioxide the spectrum of which is rich in carbon monoxide features over the entire wave-length range of each spectrograph. In contrast to the abrupt variations in exposure obtained along each of the single emulsions, a relatively uniformly exposed spectrum was obtained in each case on the mosaic as expected.

The invaluable assistance of Mr. G. E. Beale, jun., in this work is gratefully acknowledged.

R. W. NICHOLLS*

National Bureau of Standards,
Washington, D.C.

* Temporarily on leave of absence from Department of Physics, University of Western Ontario, London, Canada.

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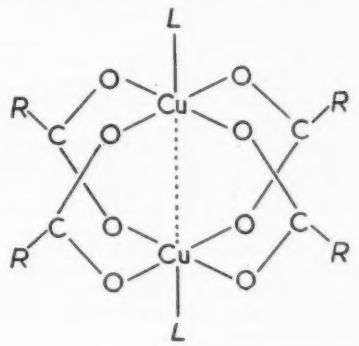
Nature of Cupric Alkanoate Solutions

THAT the cupric salts of alkanoic acids occur in the solid state in the form of dimeric molecules is shown by van Niekerk and Schoening's X-ray analysis of cupric acetate hydrate (I, $R = CH_3$, $L = H_2O$)[1] and by Martin and Waterman's magnetic studies of the acetate and some higher homologues in hydrated and anhydrous forms[2]. Tsuchida and Yamada have shown that a further characteristic of this structure is the occurrence of an absorption band about 375 mμ, polarized in the copper–copper axis, in addition to the usual 'copper band' about 700 mμ[3,4].



(I)

Martin and Waterman extended their observations to the dissolved state and showed that the dimeric structure persisted in dioxane solution, arguments from the magnetic properties being supported by cryoscopic measurements of molecular weight and the appearance of an absorption band about 375 mμ[5]. Since the anhydrous compounds were found to be insoluble in non-donor solvents (though some of the higher homologues became dispersed), the species present in solution were presumably dioxane solvates (I, $L = C_4H_8O_2$).

Further evidence of the existence of dimeric molecules in solution is provided by a study of the distribution of cupric propionate between water and chloroform in the presence of propionic acid[6], distribution constants of the form :

$$k = \frac{[\mathrm{Cu}]_{\text{aqueous phase}}}{\sqrt{[\mathrm{Cu}]_{\mathrm{CHCl_3\ phase}}}}$$

being interpreted in terms of the partition equilibrium:

$$2\ \mathrm{CuPr^+} + 2\ \mathrm{Pr^-} \rightleftharpoons \mathrm{Cu_2Pr_4}$$

Table 1. Distribution Constant and Propionic Acid Concentration

$[CuPr_2]$ (mole/l.)	0·039	0·039	0·055	0·055	0·055	0·077	0·077	0·077
[HPr] (mole/l.)	0·14	0·20	0·115	0·20	0·29	0·16	0·28	0·44
k	0·45	0·34	0·45	0·38	0·32	0·43	0·34	0·28
$k\sqrt{[HPr]}$	0·17	0·15	0·15	0·17	0·17	0·17	0·18	0·19

Variation of the values of k with propionic acid concentration was attributed to the suppression of hydrolysis, but it is now suggested that this variation, which can be expressed in the form :

$$k \propto \frac{1}{\sqrt{[\mathrm{HPr}]}}$$

(Table 1), shows that the cupric propionate is dissolved in the organic phase, not as unsolvated molecules but as the propionic acid solvate (I, $R = C_2H_5$, $L = C_2H_5COOH$), thus accounting for the insensitivity of the absorption spectra to changes of the extracting solvent. The partition equilibrium now becomes :

$$2\mathrm{CuPr^+} + 2\mathrm{Pr^-} + 2\mathrm{HPr} \rightleftharpoons \mathrm{Cu_2Pr_4(HPr)_2}$$

Since the anhydrous cupric alkanoates are insoluble in non-donor solvents, further evidence for solvation by the free acids was sought by determining their solubilities in chloroform in the presence of free acid. Table 2 shows the solubilities (determined iodimetrically) of anhydrous cupric acetate, *iso*butyrate and crotonate in the presence of the corresponding acids.

Table 2. Solubility and Free Acid Concentration (at 25° C.)

Acetate			*iso*Butyrate			Crotonate		
[HA] mole/l.	[Cu] mole/l.	$\frac{[Cu]}{[HA]}$	[HA] mole/l.	[Cu] mole/l.	$\frac{[Cu]}{[HA]}$	[HA] mole/l.	[Cu] mole/l.	$\frac{[Cu]}{[HA]}$
0·091	0·0047	0·052	0·099	0·0040	0·040	0·093	0·0069	0·074
0·180	0·0100	0·055	0·183	0·0085	0·046	0·174	0·0128	0·074
0·364	0·0180	0·049	0·367	0·0166	0·045	0·352	0·0239	0·068
0·731	0·0343	0·047	0·725	0·0375	0·052	0·713	0·0433	0·061
1·83	0·0858	0·047	1·86	0·0722	0·039			

As the free acids are known to be mainly dimeric in chloroform solution, the linear relationship between solubility and free-acid concentration shows that the dissolved species is the solvated dimer in accordance with the equilibrium :

$$\mathrm{Cu_2}A_4 + (\mathrm{H}A)_2 \rightleftharpoons \mathrm{Cu_2}A_4(\mathrm{H}A)_2$$

All these solutions have absorption bands at 675 mμ ($\varepsilon \sim 200$ per atom of copper) and 375 mμ ($\varepsilon \sim 60$ per atom of copper). The band at 675 mμ is sensitive to changes of solvate, addition of pyridine causing a shift to 710 mμ and of dioxane to 655 mμ (as found by Martin and Waterman in dioxane solution). The wide occurrence of the solvated dimeric structure in solution is shown by the observation of this pattern of absorption by the cupric compounds of the following acids : acetic, propionic, butyric, *iso*butyric, *n*- and *iso*-valeric, pivalic, caproic, octoic, lauric, stearic, β-chloropropionic, β-phenylpropionic, phenylacetic and crotonic.

The resistance of cupric formate to the formation of the dimeric structure has been studied by Martin and Waterman[7], who observed the characteristic absorption pattern in 90 per cent aqueous formic acid solution and in formic acid/acetone, the absorption bands being at 360 mμ, 745 mμ and 375 mμ, 675 mμ respectively. It now seems probable that the latter solution contains the formic acid solvate (I, R = H, L = HCOOH) and not, as they suggest, the acetone solvate and that the former contains a mixture of this with hydrated monomeric species.

D. P. Graddon

Inorganic Chemistry Department,
University of New South Wales,
Sydney.

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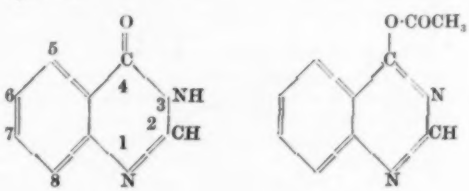
Acetylation of 4-Quinazolone

The sodium salt of 4-quinazolone[1] is known to give 3-substituted derivatives on alkylation[1]. In the hope of preparing 3-acetyl-4-quinazolone, the sodium salt of 4-quinazolone was subjected to acetylation. When carefully dried sodium salt of 4-quinazolone was made to react with acetyl chloride in dry dioxane, a colourless crystalline compound $C_{10}H_8O_2N_2$, was isolated. The same derivative was obtained by refluxing 4-quinazolone with large excess of acetic anhydride. Extreme care was necessary in excluding water during the preparation and purification of this compound.



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The new compound has high lability towards water. Slight trace of water in the solvent or exposures to moist air decomposed it into 1 mole of 4-quinazolone and 1 mole of acetic acid even at room temperature.

The reduction of this labile compound with lithium aluminium hydride gave 4-quinazolone in good yield. As an *N*-acetyl group would be expected to give an

N-ethyl group and an O-acetyl group would be de-acetylated, the results of the lithium aluminium hydride reduction imply that the labile derivative is 4-acetoxyquinazoline (II).

R. MIRZA

Akers Research Laboratories,
Imperial Chemical Industries, Ltd.,
Welwyn, Hertfordshire.
April 19.

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BIOCHEMISTRY

Development of 5-Hydroxytryptophan Decarboxylase Activity in Rat Kidney

THE studies of Udenfriend and his co-workers[1] indicate that tryptophan is first oxidized to 5-hydroxytryptophan and then decarboxylated, resulting in the formation of 5-hydroxytryptamine. The latter reaction requires the presence of a specific enzyme, 5-hydroxytryptophan decarboxylase[2]. The purpose of the present communication is to describe the development of this enzyme system in the kidneys of fœtal, new-born, and adult rats.

In these experiments, albino rats of the Sprague–Dawley strain were used. All animals were killed by a sharp blow on the head and bled from the neck. The kidneys were removed and homogenized in 4 ml. of distilled water with a Potter–Elvehjem tissue grinder. Enzyme activity of kidney and adult rats was determined individually. In the case of rats younger than 21 days of age, the kidneys from litter mates were pooled and homogenized in 3 ml. of distilled water. The incubation mixture, consisting of 10 μmoles of 5-hydroxy-DL-tryptophan (Sigma Chemical Company) in 2·7 ml. of 0·1 *N* sodium pyrophosphate buffer, *p*H 8·0, was first gassed with nitrogen for 5 min. After agitation with nitrogen for 10 min., 0·3 ml. of rat kidney homogenate was added and the mixture was shaken in a nitrogen atmosphere at 38° C. in a Dubnoff metabolic incubator for a period of 2 hr. The reaction was stopped by the addition of 3·0 ml. of 10 per cent trichloracetic acid. After centrifugation, 3·0 ml. of the supernatant was removed, and the 5-hydroxytryptamine formed was determined by the colorimetric method of Udenfriend *et al.*[2]. All the experiments were carried out in duplicate. The results were expressed as μmoles of 5-hydroxytryptamine formed per 100 mgm. dry weight of kidney per hr.

Table 1 shows the 5-hydroxytryptophan decarboxylase activity of kidneys of rats of various ages. The results indicate that the enzyme was inactive in the fœtus and shortly after birth, and gradually increased to adult-levels over a period of several weeks.

Table 1. KIDNEY 5-HYDROXYTRYPTOPHAN DECARBOXYLASE ACTIVITY IN RATS OF DIFFERENT AGES

Age	No. of exp.	No. of animals	5-Hydroxytryptophan decarboxylase activity*
Fœtal†	3	45	0
1 day	3	23	0
2–5 days	4	24	0·21 ± 0·21
7–12 days	5	26	0·38 ± 0·10
21–23 days	7	21	0·66 ± 0·13
33 days	4	8	1·19 ± 0·47
Adults	14	14	1·34 ± 0·58

* Mean values expressed as μmoles 5-hydroxytryptamine formed per 100 mgm. of dry weight of kidneys per hr.
† 1–3 days before term.

Buzard and Nytch[4] have shown that pyridoxal phosphate is a co-factor for rat kidney 5-hydroxytryptophan decarboxylase. The possibility that the low activity of this enzyme in fœtal and new-born rat kidneys may be caused by a deficiency of this co-factor was tested by adding 0·1 and 0·8 μmole pyridoxal phosphate to the incubation mixture. Table 2 shows that although excess amounts of pyridoxal phosphate increased the formation of 5-hydroxytryptamine two- to three-fold in the older and adult rat kidney homogenates, as has previously been reported[4], the addition had only a minimal effect in the fœtal and new-born homogenates. This was also tested *in vivo* by the intraperitoneal injection of 50 mgm. of pyridoxine hydrochloride to a pregnant rat three days prior to delivery. Assay of 5-hydroxytryptophan decarboxylase in the new-born rat kidney homogenate in this litter failed to show any demonstrable enzyme activity.

Table 2. EFFECT OF PYRIDOXAL PHOSPHATE SUPPLEMENTATION UPON 5-HYDROXYTRYPTOPHAN DECARBOXYLASE ACTIVITY

Age	5-Hydroxytryptophan decarboxylase activity*		
	Without supplementation	0·1 *μM* PP added	0·8 *μM* PP added
Fœtal	0	0·09	0·15
1 day	0	0	—
2 days	0	0·19	0·19
3 days	0·40	0·43	0·62
11 days	0·44	0·62	0·71
21 days	0·83	3·10	—
21 days	0·78	2·85	—
23 days	0·65	1·56	1·77
Adult	1·34	3·01	—
Adult	0·82	2·38	—
Adult	0·65	1·84	—
Adult	0·69	1·62	1·57

* Mean values expressed as μmoles of 5-hydroxytryptamine formed per 100 mgm. dry weight of kidneys per hr.

Finally, reports have appeared showing the inhibition of 5-hydroxytryptophan decarboxylase by carbonyl reagents, metal chelating agents, cupric ions, phenylalanine derivatives, substituted indoles and norepinephrine. Because of this possibility, mixture experiments using rat kidney homogenates were carried out with the following results, expressed in terms of 5-hydroxytryptamine formed: 0·3 ml. fœtal homogenate, 0; 0·15 ml. fœtal and 0·15 ml. adult mixed, 0·40 μmole; and 0·3 ml. adult, 1·06 μmoles. In order to rule out the possibility of non-protein inhibitors, rat kidney homogenate from a young animal was boiled at 100° C. for 3 min. The supernatant had no effect on the 5-hydroxytryptophan decarboxylase activity in adult rat kidney. While this does not positively rule out the possibility of an inhibitor, the evidence would seem to suggest that the low activity of 5-hydroxytryptophan decarboxylase activity in fœtal and new-born rat kidney probably represents a low inherent activity of the enzyme itself[4].

A deficiency of 5-hydroxytryptophan decarboxylase in the fœtal rat kidney is of interest because of the part the enzyme plays in the central nervous system. For example, Amin *et al.*[5] have shown the synthesis of 5-hydroxytryptamine from its immediate precursor 5-hydroxytryptophan and that it is stored in particular regions of the grey matter of the brain[6]. In animal experiments, Feldberg and Sherwood[6] have described characteristic changes in behaviour following the injection of 5-hydroxytryptamine into the cerebral ventricles. The inhibition of 5-hydroxytryptophan decarboxylase by phenylalanine metabolites has also been demonstrated *in vitro*[7]. This

may in part account for the lowered levels of circulating 5-hydroxytryptamine and urinary 5-hydroxyindoleacetic acid in patients with phenylketonuria. The pattern of development of this enzyme system in the fœtal brain and the part this may play in the central nervous system in phenylketonuria is being explored.

In any event, the decreased activity of 5-hydroxytryptophan decarboxylase in fœtal and new-born rat kidney can now be added to the growing list of enzyme deficiencies in the new-born period[3], which now includes glucose-6-phosphatase, glucuronyl transferase, histidase, and the hepatic tyrosine oxidation and phenylalanine *p*-hydroxylase system.

Acknowledgment is made of grants by the U.S. Public Health Service *M*-2630, and the Illinois Mental Health Fund.

Irene Huang
Sheila Tannenbaum
David Yi-Yung Hsia

Genetic Clinic, Children's Memorial Hospital, and Department of Pediatrics, Northwestern University Medical School, Chicago, Illinois.

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Non-Enzymic Reactions of Indoles with Coenzyme I

In the course of studies of possible enzymically catalysed reactions of coenzyme I (diphosphopyridine nucleotide) with 5-OH-tryptamine (serotonin), tryptamine and tryptophan[1], it was observed that these indoles react non-enzymically with coenzyme I. Thus, when 5-OH-tryptamine was added to a solution of coenzyme I, an intense yellow coloration appeared. Tryptamine and tryptophan also reacted in the same manner, but larger concentrations of the latter substances were required in order to give the same intensity of colour. Spectral characteristics of the coloured materials are shown in Fig. 1.

The intensity of the colour developed (in the region 450–310 mμ) depended on the *p*H, the concentration of coenzyme I and the concentration of the indoles. At very low *p*H values, interaction occurred only to a very limited extent, as judged from the intensity of the colour. In the *p*H range 4–8, differences in the colour intensity of equally concentrated reaction mixtures were very small. At higher *p*H values, and with serotonin as a reactant, the intensity of the colour developed increased rapidly. Although formation of the coenzyme I–tryptamine complex rendered this base soluble even at *p*H values above the pK' (about 9·7) for the protonation of its aliphatic amine, it was difficult to carry out quantitative work with tryptamine in this *p*H range (that is, above *p*H 9·0). With respect to the dependence of the colour intensity on the concentration of the reactants, Beer's law was followed within a wide range of variation of the concentration of either reactant. N-methyl-nicotinamide was found to react in a similar manner as coenzyme I with the indoles.

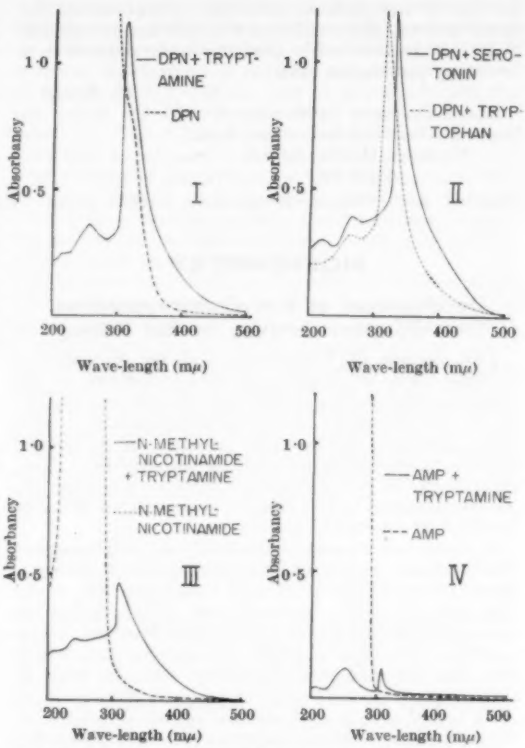

Fig. 1. Interactions of indoles with coenzyme I (DPN) (I and II); *N*-methyl-nicotinamide (III); and adenosine-5′-phosphate (AMP) (IV). These three compounds were used at concentrations of 5 μmoles per ml. Spectral lines in the absence of indoles correspond to differences (absorbancies) between the absorbance of buffered solutions of the three compounds (experimentals) and the absorbance of the buffer alone (blank). The various indoles were used at concentrations of 20 μmoles per ml. Spectral lines in their presence represent differences (absorbancies) between the absorbance of buffered indole-containing solutions of the three compounds (experimentals) and the absorbance of the respective buffered indole solutions (blanks). All systems were buffered with *tris*-hydroxymethylaminomethane/hydrochloric acid at *p*H 7·8 (400 μmoles per ml.). Absorbancies were taken with a *DK*$_1$ Beckman recording spectrophotometer

The experimental evidence indicates that a probable site of reaction of the indole nucleus is the pyrrolic nitrogen in its deprotonated form. The rise of the reactivity of the indoles with increasing *p*H (see above) further supports this view. Apparently, the pyrrolic nitrogen of the indoles acts as a nucleophilic agent, attacking an electrophilic centre in coenzyme I. The participation of the pyridine moiety of coenzyme I in the reaction is indicated by the similar reaction observed with N-methyl-nicotinamide. In analogy to known reactions of pyridinium structures (for example, coenzyme I) with a number of nucleophilic agents like cyanide[2,3], carbonyl compounds[4], imidazoles[5], etc., the reacting site of the nicotinamide moiety of coenzyme I is probably C4. However, in addition to changes in the visible and near ultra-violet region, the reaction mixtures exhibited also profound changes in the far ultra-violet region of the spectrum. For example, the theoretical absorbancy of a coenzyme I solution containing 5 μmoles per ml. at 260 mμ would be about 90·000 (ref. 6). As shown in Fig. 1, I, the value

obtained when a coenzyme I–tryptamine solution was read against an equally concentrated solution of tryptamine was about 0·370, corresponding to a decrease of approximately 243 times. The theoretical absorbance of a tryptamine solution containing 20 μmoles per ml. at 260 mμ would be about 65·000. This creates difficulties in explaining the drop of absorbancy solely on the basis of changes of the indole in the coenzyme I–tryptamine mixture. Since similar changes in the far ultra-violet spectrum are also observed in adenosine-5′-phosphate–tryptamine mixtures (Fig. 1, IV), the adenine moiety of coenzyme I seems to be involved in these interactions.

Attempts to isolate the products (complexes) of these interactions and study their properties are now in progress.

This work was supported in part by Grant No. *E*-2436 from the National Institute of Allergy and Infectious Diseases, National Institutes of Health, United States Public Health Service, Grant No. *G*-7644 from the National Science Foundation, Washington, D.C., and Grant No. *P*-241 from the American Cancer Society, Inc.

S. G. A. Alivisatos
G. A. Mourkides
A. Jibril

Mount Sinai Medical Research Foundation and Hospital, the Chicago Medical School, Chicago, Illinois. Dec. 22.

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Nonulosaminic Acid (Sialic Acid) in Protists

Nonulosaminic acid[1], a group of simple and substituted 9-carbon sugars containing nitrogen, was thought restricted to mammals until it was found in the supernates of *Escherichia coli* and *Citrobacter freundii* cultures, but not in the supernates of *Salmonella*, *Shigella*, *Pneumococcus* or *Bacillus* cultures[2]. Nonulosaminic acid has now been found in the cells of *E. coli*[3], *Neisseria meningitidis*, *Salmonella dahlem*, and *S. djkarta*[4].

We have examined thirty species of protists for nonulosaminic acid. A minimum of 100 mgm. of cells, dried at 60° C., were hydrolysed in 1 *N* sulphuric acid for 1 hr. at 100° C. and at a concentration of 10 per cent (w/v): 0·2 ml. of the hydrolysate was analysed for nonulosaminic acid by the Warren method[5]. Presence of nonulosaminic acid was confirmed by descending paper chromatography of the Warren chromophore with 10 per cent ethanol in water as solvent. The interfering deoxyribose chromophore remains at the starting line and fluoresces white with a Wood's lamp; the nonulosaminic acid chromophore, R_P 0·11, fluoresces pink.

Nonulosaminic acid was found only among the Gram-negative bacteria (Table 1).

Table 1. Presence of Nonulosaminic Acid in Protists

	Gram reaction	Acid content
Schizomycetes		
Pseudomonadales		
Pseudomonas salinaria	−	−
Thiobacillus thioxidans	−	−
,, *thioparus*	−	−
Rhodopseudomonas palustria	−	+
,, *spheroides*	−	++
Chlorobium limicola	−	+
Eubacteriales		
Escherichia coli	−	++
Aerobacter aerogenes	−	++
Proteus vulgaris	−	+
Klebsiella pneumoniae	−	++
Lactobacillus leichmannii	+	−
Bacillus stearothermophilus	+	−
,, *subtilis* (four strains)	+	−
,, *megaterium*	+	−
,, sp. (three strains)	+	−
Sarcina lutea	+	−
Myxobacteriales		
Cytophaga sp.	−	+
Beggiotales		
Leucothrix mucor		−
Ascomycetes		
Brewers' yeast		−
Saccharomyces carlsbergensis		−
Algae		
Cyanidium calidarum		−
Anacystis nidulans		−
Synechococcus sp.		−
Protozoa		
Euglena gracilis		−
Ochromonas malhamensis		−
,, *danica*		−
,, *minuta*		−
Crithidia fasciculata (two strains)		−
Tetrahymena pyriformis		−

++, More than 2 per cent nonulosaminic acid; +, 1–2 per cent; −, acid not detected.

Gram-negative bacteria share common features besides the Gram reaction; they elaborate endotoxins causing hæmorrhage in mouse tumours[6] and substances which inhibit agglutination of human blood groups[7]. Should nonulosaminic acid be generally distributed among Gram-negative but not Gram-positive bacteria it would be useful as a phylogenetic marker, especially if it should prove to have a very restricted distribution among Gram-positive bacteria. This is under study.

We thank the U.S. Public Health Service for financial support, Dr. Donald Watson of the Rackham Arthritis Unit, University of Michigan, for a sample of pure nonulosaminic acid, and Drs. K. Eimhjellen, J. Gibson, C. Van Baalen, and W. Vishniac for generous samples of some of the protists studied.

S. Aaronson*
T. Lessie

Biology Department,
Queens College, Flushing 67, New York,
and Haskins Laboratories, Inc.,
305 East 43rd Street,
New York 17.

* National Science Foundation, Science Faculty Fellow.

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Changes in the Levels of Adenosine Triphosphate and Glycogen in the Liver caused by Protein Administration

During a study of the influence of diet on adenosine nucleotide metabolism in the liver of the rat, we have observed that the concentration of adenosine triphosphate in the livers of well-fed animals falls rapidly when they are given a meal of protein. This change

Table 1. Effect of Previous Level of Energy Intake and of Protein Administration on the Concentration of Adenosine Triphosphate and of Glycogen in the Liver of the Rat

Preceding diet	State when killed	Adenosine nucleotides (μmoles/gm. liver)			Glycogen (gm./100 gm. liver)
		Adenosine triphosphate	Adenosine diphosphate	Adenosine monophosphate	
Low energy	Fasting 10 hr.	0·57 ± 0·07	0·92 ± 0·08	2·16 ± 0·07	—
High energy	Fasting 10 hr.	1·65 ± 0·16	0·91 ± 0·08	1·45 ± 0·12	2·3 ± 0·3
High energy	Fed casein 2 hr. before killing	0·45 ± 0·06	0·94 ± 0·16	1·68 ± 0·11	0·6 ± 0·2

On the day of killing, the rats were fed meals of low or high energy content at 9 a.m. and were killed at 7 p.m. Some of the animals on the high energy intake were also fed 2·5 gm. casein at 5 p.m. The adenosine nucleotide data are the means (± *S.E.*) of three experiments, and the glycogen data are the means (± *S.E.*) of six experiments. The adenosine triphosphate concentration for the high energy fasting group was significantly greater than that of the other two groups ($P < 0.01$) and the adenosine monophosphate concentration was significantly lower than that of the low energy group ($P < 0.01$), when analysed by the 't' test for differences between groups. The glycogen content of the liver was significantly reduced by protein administration ($P < 0.01$). All other differences were not statistically significant ($P > 0.05$).

is associated with a reduction in liver glycogen content.

Female albino rats weighing approximately 180 gm. were fed twice daily on synthetic diets similar to those used by us in previous experiments[1]. At 9 a.m. they ate 1 gm. of a vitamin–mineral–roughage mixture and 5 gm. of carbohydrate. At 5 p.m. they received 4·2 gm. of a protein–carbohydrate–fat mixture. The total diet of these animals provided 41 kcal./day and in Table 1 they are referred to as the high-energy group. Some animals were fed on the same diet without the carbohydrate in the morning meal. These rats received a total energy intake of 21 kcal./day and are referred to as the low-energy group. The rats rapidly learned to eat these meals promptly and, after a few days, the evening meal was omitted and animals from each group were killed at 7 p.m. in the fasting state, that is, 10 hr. after they had eaten a morning meal which either provided abundant energy as carbohydrate or else contained very little energy. In addition, some of the group on the high-energy intake were given 2·5 gm. of casein (Glaxo), which was made into a paste with 0·1 gm. sodium bicarbonate and was fed 2 hr. before killing. In this way, livers were obtained from three groups of animals: (*a*) a group fasting after a meal low in energy content; (*b*) a group fasting after a meal rich in energy content; (*c*) a group on the higher level of energy intake which were actively absorbing amino-acids from the gut at the time of death.

The livers were analysed for adenosine nucleotides (adenosine tri-, di- and mono-phosphates) by methods described previously[1]. The results (Table 1) confirm our earlier observation[1] that the energy content of the diet has a decisive influence on the concentrations of adenosine nucleotides in the liver. Comparison of the data for the two fasting groups shows that, even although 10 hr. had elapsed since consumption of the last meal, the livers of the rats receiving the higher energy intake had a considerably greater concentration of adenosine triphosphate and a smaller concentration of adenosine monophosphate. However, casein administration 2 hr. before death caused the adenosine triphosphate concentration in the livers of this group to fall to the level observed among animals on the low-energy intake. This was accompanied by a sight increase in adenosine monophosphate concentration which was not statistically significant.

In a separate series of experiments, we observed the effect of these dietary conditions on the glycogen content of the liver. Glycogen was extracted from the liver with 30 per cent potassium hydroxide, precipitated with ethanol and estimated by the anthrone procedure[2]. This showed (Table 1) that rats fasting 10 hr. after receiving the high-energy diet still had a considerable amount of glycogen in their livers, but when animals on this diet received casein 2 hr. before death, a large reduction in liver glycogen content occurred.

Thus the absorption of products of protein digestion causes a marked decrease in the concentration of certain constituents involved in energy metabolism in the liver. These changes occur at an early stage in the absorption process, since it was observed in these experiments that the bulk of the ingested casein was still present in the stomach at the time of killing.

Catherine M. Clark
G. A. J. Goodlad

Department of Biochemistry,
University of St. Andrews.

J. Chisholm
H. N. Munro

Department of Biochemistry,
University of Glasgow.

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Reversible Transformation of Gelatin to the Collagen Structure

The conversion of soluble collagen (tropocollagen, procollagen, acid-extract collagen) to gelatin has been shown to involve the separation of the three-chain coiled-coil structure of the collagen molecule into single peptide chains[1,2] each having the disordered random-coil configuration. The universal experience with gelatins has been that these disordered chains could not be returned to the complete native collagen structure, although optical rotation, polarized infra-red, and wide-angle X-ray diffraction studies of cooled gelatin solutions or gels showed that partial ordering and helical folding of the chains could occur in localized regions[3,4]. The principal factor ruling against the complete reversibility of the collagen–gelatin transition was the requirement for the proper juxta-position and recoiling of the three complex peptide chains.

Recent studies of the collagen degradation process[5,6] and the structure of high molecular weight gelatins[7,8] gave indirect evidence that some features of the structure, and particularly the interchain cross-linkages present in native insoluble collagen, might be retained in the soluble degradation products. This suggested to us that if the relative peptide chain

alignments were retained near the cross-linkage sites, treatments which induced the collagen fold might give rise to ordered collagen-like fibres. We have carried out such experiments and have produced ordered collagen-like fibres.

Our standard for judging whether we had achieved recovery of the long-range collagen structure from gelatin solutions was the preparation of fibrous precipitates that exhibited the cross-striated pattern typical of native collagen fibres when viewed in the electron microscope. The only possibility for the misinterpretation of such observations was that some collagen fibres might have been peptized by the gelatin and carried through the extraction and recovery procedures. We believe that the sequence of experimental steps outlined below eliminated this possibility of misinterpretation of the electron micrographs.

Native bull-hide corium collagen, purified as described previously[9], was extracted in an isoionic suspension (pH $\sim 6{\cdot}0$) at 60° for 1 hr. The contraction temperature of this collagen preparation was 55·8–60·6° for individual fibres[6]. The solution of solubilized gelatin (~ 7 per cent)[5] was filtered through sintered glass and then fractionated by an ethanol–sodium chloride coacervation technique[5] into six successive fractions. Any suspended collagen carried along through the filter was precipitated with the first fraction. The remaining fractions were collected and the coacervates were dissolved in warm water (40–45°). The gelatin was recovered from these solutions by precipitation with acetone. These precipitates were washed with cold water, then redissolved at 40°, and reprecipitated with acetone. The third fraction, which contained neither the lowest nor the highest molecular weight material, was chosen for the following recovery experiments.

The dried acetone precipitate was dissolved in 0·1 M potassium chloride at 40° by shaking for 1 hr. The solution, $[\alpha]_D^{40} = -136°$, was clarified by centrifugation in a Spinco preparative ultracentrifuge for 1½ hr. at 144,000g and room temperature. A small, translucent gelatinous sediment was discarded. The clear solution was transferred immediately to a cold room at 4° and was kept there for 20 hr. The solution set to a firm clear gel. The gel was placed in a 40° bath and held there without shaking. Within 12 min., as the gel melted, a fine turbidity developed and within 1 hr. floccules appeared. These were collected by low-speed centrifugation at room temperature. The precipitate was white and fibrous in contrast to the translucent gel obtained in the earlier higher-speed centrifugation. The clear supernatant gelled when cooled to 4° but remained clear when rewarmed.

The fibrous precipitate was examined in an electron microscope and clearly showed (Fig. 1) the typical collagen cross-striations. The fibre width, however, was variable, and the characteristic periodicity averaged about 610 Å. The fibres were readily soluble in 6·0 M urea at room temperature but could be held indefinitely at 40° in water or in dilute salt solution. This behaviour of the heat-precipitable gelatins resembles that of neutral salt-soluble collagen.

The fibres represented about 10 per cent of the protein content of the fraction III solution that remained after the initial high-speed centrifugation. The low negative optical rotation of this solution indicated the absence of the collagen helical structure in the dissolved gelatin molecules.

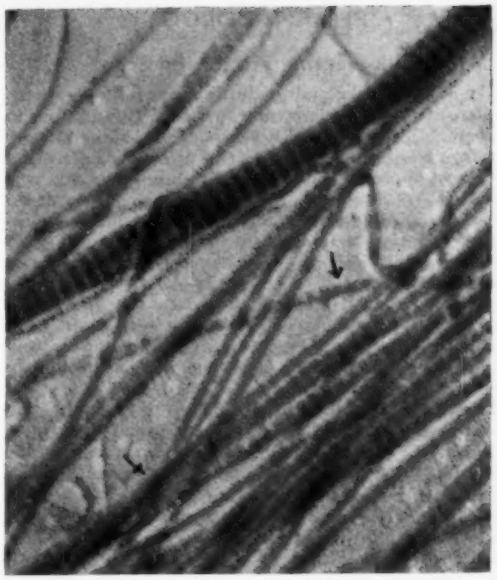

Fig. 1. Electron micrograph of fibres obtained from Fraction III gelatin. Chromium shadowed (× 38,700). The main periodicity is 610 Å., but there is also clearly visible a definite sub-periodicity (arrows) of ~ 210 Å. in the thinner fibrils

Attempts have been made to prepare fibrous precipitates by this and similar procedures with both commercial and other specially prepared gelatins. Only those shown by characterization studies to have the multi-chain structure, and therefore to contain strong interchain cross-linkages, yielded fibrous precipitates. These observations are interpreted as verification of our earlier suggestion that high-molecular weight gelatins are cross-linked networks rather than completely random coils[5,6,8]. Since the chains are held in the proper register whereby they can be re-ordered to the native configuration, the cross-linkages must be inherent in the insoluble collagen and not randomly induced by the degradative treatment.

The quantitative aspects of these experiments are being examined. These, and the necessary characterization studies, will be described in more detail elsewhere.

We are indebted to Dr. L. S. Fosdick of the Northwestern University Dental School for so generously allowing us to use his electron microscope facilities.

ARTHUR VEIS
JEROME COHEN

Central Research Laboratories,
Research Division,
Armour and Co.,
Chicago 9.

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PHARMACOLOGY

Milk-ejecting Action of Ergot

It is known that adrenalin inhibits milk ejection[1]. In an attempt to determine whether this inhibition is central or peripheral a series of experiments were performed on rats. The effect of prior administration of ergotamine on the adrenalin-induced block was studied. In the course of this investigation it appeared that ergotamine and ergometrine also had a milk-ejecting action of their own. This property of ergot causing milk ejection does not appear to have been described before.

Milk ejection has been assessed by the increase in weight after suckling of the young rats (8–10 days after birth) separated overnight. Adrenalin as well as atropine and alcohol block the ejection of milk in rats by preventing the release of oxytocin (personal observation). Adrenalin in doses of 1 μgm. and more when administered intraperitoneally always inhibits the milk-ejecting reflex, but when ergotamine ('Gynergen' Sandoz, Ltd.) or ergometrine (Sandoz, Ltd.) is administered to the mother (200–250 gm.) in doses of 50–100 μgm. intraperitoneally half an hour before the administration of adrenalin there is no inhibition of milk ejection. When the lactating mothers were injected with an ergot preparation just prior to suckling the litters gained more weight after suckling than they did normally. The fact that ergometrine also, in addition to ergotamine, has this property of causing milk ejection indicates that ergot does so, not by specifically reversing the action of adrenalin but by itself causing milk ejection. When adrenalin and ergotamine are administered simultaneously to the mother just before suckling there is no inhibition of milk ejection. The action of ergometrine and ergotamine was then studied on six litters where the milk ejection reflex had been blocked by prior administration of atropine (60–120 μgm. intraperitoneally immediately before suckling) and 7·5 per cent alcohol (5 ml./100 gm. body-weight orally 30 min. prior to suckling). It was found that when ergotamine or ergometrine was administered to the mother just prior to suckling neither alcohol nor atropine caused any inhibition of milk ejection. Normally a dose of 3–10 μgm. atropine causes a complete inhibition of milk ejection which can only be reversed by oxytocin. Fig. 1 shows the increase in weight of a litter after suckling when no drug was administered as compared to the increase in weight of the same litter on another day when adrenalin (1 μgm.) and, on another day, adrenalin and ergometrine (50 μgm.) were administered just prior to suckling.

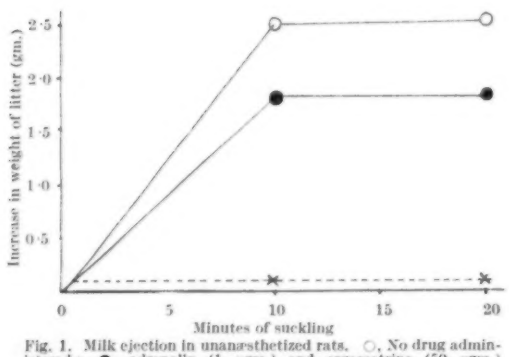

Fig. 1. Milk ejection in unanæsthetized rats. ○, No drug administered; ●, adrenalin (1 μgm.) and ergometrine (50 μgm.) intraperitoneally; ×, adrenalin (1 μgm.) intraperitoneally

The results described in brief indicate that ergot, in addition to its many actions, also causes milk ejection. It is unlikely that ergot causes milk ejection by releasing oxytocin, and we suggest that ergot, when administered to rats, has a direct action on the lactating myoepithelium and causes its contraction. Ergot has for long been known to possess an oxytocic action on the uterus, and it appears to possess another oxytocin-like action causing milk ejection.

Ranjit Roy Chaudhury
Mandakini B. Dikshit

Department of Pharmacology,
All India Institute of Medical Sciences,
Safdarjang,
New Delhi, 16.

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Indian Substitutes of Male Fern in Pharmacognosy

Dryopteris filix-mas (L.) Schott, commonly known as the male fern, is a good tænicide and is included in the pharmacopœias of all countries and also in the International Pharmacopœia. India, with her vast resources of drug plants, has many indigenous species of *Dryopteris* growing in the Himalayas, although the true male fern is not indigenous. With the view of finding suitable Indian substitutes of the official drug, phytochemical and pharmacognostical investigations on the following 18 members of the family Aspidiaceae were carried out. *Dryopteris hirtipes* (Bl.) O. Ktze., *D. scotti* (Bedd.) Ching, *D. cochleata* (Don) O. Ktze., *D. barbigera* (Moore) O. Ktze., *D. serratodentata* (Bedd.) Hayata, *D. fibrillosa* (Clarke) Hand-Mzt., *D. rosthernii* (Diels) C. Chr., *D. paleacea* (Don) Hand-Mzt., *D. blanfordii* (Hope) C. Chr., *D. chrysocoma* (Christ) C. Chr., *D. ramosa* (Hope) C. Chr., *D. pulvinulifera* (Bedd.) O. Ktze., *D. splendens* (Hk.) O. Ktze., *D. sparsa* (Don) O. Ktze., *Ctenitis apiciflora* (Wall) Ching, *C. nidus* (Clarke) Ching, *Hypodematium crenatum* (Forsk) Kuhn, *Cyrtomium falcatum* Presl.

Chemical analyses have shown that all the species of *Dryopteris* (with the exception of *D. sparsa*) and both the species of *Ctenitis* contain filicin much above the official requirement (B.P. and U.S.P. require not less than 1·5 per cent of filicin in the crude drug). *Hypodematium* and *Cyrtomium* are practically useless. Of particular interest is the species *D. chrysocoma*, which contains the maximum amount of the active principle (4·3 per cent of filicin in the crude drug). This, together with three other species, namely, *D. ramosa* (3·8 per cent of filicin in the crude drug), *D. barbigera* (2·2 per cent of filicin in the crude drug), and *D. cochleata* (1·8 per cent of filicin in the crude drug), which grow prolifically in a wild state, could be commercially exploited to great advantage.

A valuable field test for species rich in the active principle is found to be a greenish tinge of the cut surface of the rhizome and stipe bases, which colour is retained long after drying. Species poor in this principle either show no colour or turn brown soon after cutting.

An intensive pharmacognostic study has revealed that the species containing oleoresin and filicin

invariably show large schizogenously developed cavities within the ground-tissue of the rhizome and the petiole bases. Into these project one to several secretory glands. The species like *D. sparsa*, *Hypodematium crenatum* and *Cyrtomium falcatum* are devoid of these structures, and also the active principle. The secretory glands are of different shapes and sizes in different species but functionally similar. In both species of *Ctenitis* they are elongated cylindrical in contrast to the clavate or pyriform ones in *Dryopteris* species. The former type may probably characterize the genus *Ctenitis* but this requires confirmation by study of more species.

Anatomically, the rhizome and petiole show the usual fern structure. Some species are, however, characterized by the presence of dark patches of sclerenchyma (sclerotic nests) in the ground-tissue of either or both of these structures. These are found to serve as useful criteria for diagnosis. A key based on all the histological characters taken together is being formulated for the differentiation of the species.

P. N. Mehra
T. C. Mittal

Department of Pharmacognosy,
Panjab University,
Amritsar.

PHYSIOLOGY

Korotkov's Sounds : Action of the Heart

Development of work upon Korotkov's sounds, described by me[1], has led to the following explanation of the action of the human heart.

The right and left sides of the heart should each be regarded as the mechanical analogue of a reflex klystron, such as described by Bleaney and Bleaney[2]. The right and left atria on one hand and the pulmonary sinuses and the aortic sinuses on the other constitute cavity resonators wherein contraction and dilatation of the walls and apertures generate force fields through which flows the blood. The action of the left side of the heart will be described in the first instance, although that of the right side is similar.

The function of the left atrium is to set the blood into motion ; that of the orifice of the mitral valve is to produce velocity modulation of the stream entering the left ventricle during diastole. The cavity of the ventricle is a drift space in which fast particles of blood travel farther from the mitral valve than slow particles, before being brought to a halt on the completion of ventricular diastole. It is assumed that at the onset of atrial systole, the ring of the mitral valve is of somewhat less diameter than at the end of atrial systole ; throughout atrial systole the diameter of the ring increases so that the velocity of the stream decreases.

The blood impinges upon the ventricular wall, by which it is reflected and focused upon the aortic valve. The correct angle of incidence is maintained by the papillary muscles and chordæ tendinæ attached to the mitral valve which guides the flow. At ventricular systole, blood that has travelled farthest is exposed to accelerating force for longer time than blood that has travelled a shorter distance to gain contact with the ventricular wall and, after reflexion, the former is still equivalent to fast particles ; the latter to slow. Because of the greater excursion, fast particles are retarded in transit and join slow particles, likewise reflected, which pass through the mitral valve half a period later. This results in alternate attenuation and bunching of the stream flowing through the aortic valve and in the aortic sinuses.

Variations of diameter of the ring of the aortic valve, visible on cardio-angiography, have the effect of accelerating the attenuations and retarding the bunches, this constituting density modulation. In an ordinary fluid, of which the bulk modulus of elasticity is high, very slight variations of density would occur in these circumstances. With blood, however, it is probable that gas bubbles form inside the envelope of the red blood corpuscles, permitting an appreciable 'compressibility'. The pressure, of course, will rise with increase of density and conversely.

More power is taken from the stream during the retardations than is lost during the accelerations, with a gain which is utilized to maintain resonance in the aortic sinuses and a pulsatile flow in the coronary arteries. In addition, there is a shock wave, transmitted by the aorta and coronary arteries, arising from the forces of cavitation in the aortic sinuses.

By analogy from the klystron, the mitral and aortic valves will be out of phase by $(n + \frac{1}{4})$, where n is an integer or zero. Closure of the mitral valve does not coincide with the state of smallest diameter of its orifice, the peculiar structure of the valve making this possible. The aortic valve, on the other hand, closes when the diameter of the ring of the valve is least, accounting for the differing arrangement of the cusps.

It will be seen that the mitral valve is acting as a buncher, the aortic valve and sinuses as a catcher, corresponding to the resonators of the klystron, which are so named. More generally, these functions would appear to be subserved, respectively, by the sinospiral and bulbospiral embryological systems of the heart. The tubular heart, from which the 'reflex heart' develops, is presumably analogous to a straight-through klystron.

The iron-containing substance in cardiac muscle is probably of the nature of a Berthillode compound, for an explanation of which term reference may be made to Partington[3]. On the flow of oxygenated blood through the coronary system, following systole, the lattice-work of the compound increases in diameter as it takes up oxygen, thus increasing the volume of the cavity of the ventricle in an active manner. The shock wave of the second heart sound overcomes thyxotropism in the cardiac musculature, so facilitating ventricular diastole.

Energy from the main blood stream is fed back into this mechanism through the coronary arteries, which also supply the wall of the atrium and the musculature of the mitral orifice, whereby the resonators are coupled.

The two systems will now be assumed to be overcoupled so that the heart is regarded not only as an oscillator but as possessing also the property of self-oscillation. Regeneration is effected through the oxidation of carbohydrate, a process which provides energy to drive the ventricles, or repellors, removing oxygen from the lattice-work which shrinks during systole.

A function of the autonomic nervous supply to the heart is that of tuning the resonators, which is assisted by the apposition of the aortic and mitral valves. In a klystron, separate resonators are difficult

to tune: correct phasing is essential in such a device and more easily achieved by the reflex principle.

The right atrium and ventricle behave in a manner similar to the left with the exception that power, taken from the stream, is transmitted solely as a pressure wave by the pulmonary artery. The tricuspid valve acts as a buncher while the pulmonary valve and sinuses act as a catcher, each being in phase and paired to form a set with the corresponding valve of the left side. On each side, the shock wave of the first heart sound overcomes thyxotropism of the atrium.

The wave-mode of the oscillator is stabilized by the conducting system of the heart, which is comparable to the strapping of a magnetron. Mode jumps occur in extrasystole, differing values of n explain the varying grades of heart block but variation of each element of the $(n + \frac{3}{4})$ phase rule is also physiological.

J. E. Malcolm

Royal Air Force Hospital,
Ely.

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Potential Oscillations in the Lower Olfactory Pathway of the Toad

In the olfactory bulb of the hedgehog and the rabbit, Adrian[1,2] found that the potential waves evoked by olfactory stimulation take shapes of potential oscillation. It was presumed that the waves were developed by synchronized activity in the dendritic region of the bulb. Later, he[3] recorded the similar potential in the olfactory epithelium of the rabbit, and found that the potential pattern in the epithelium has all the features of that appearing in the bulb. In the experiment, Adrian[3] did not record the potentials in the epithelium and the bulb simultaneously; but from the similarity he presumed that the mechanism which produces the potential oscillation in the bulb originates in the olfactory epithelium. In the olfactory epithelium of the frog, Ottoson[4] found that rhythmic waves sometimes superimpose on the crest of the slow potentials produced by odour stimulation. He presumed that they are identical to the potential oscillations found by Adrian[1-3].

Since the toad (*Bufo vulgaris japonicus*) has long olfactory nerves, potentials can be recorded in the olfactory epithelium, nerve and bulb simultaneously. By olfactory stimulation, potential oscillations appeared in these tissues as well (Fig. 1). Those which appeared in the olfactory nerve and bulb are identical with one another in frequency, phase and shape. Consequently, it is apparent in the toad that the potential oscillations in the bulb originates in, or before, the olfactory nerve. However, the similar potential oscillations have never been found in the olfactory epithelium of the toad. Thus, our finding in the toad partly supports Adrian's assumption. On the other hand, the potential oscillation in the olfactory epithelium of the toad usually appeared superimposed on the slow potential which was reported by Takagi and Shibuya[5-7]. It has higher frequency than the potential oscillations in the nerve and bulb, and is different in shape from the latter

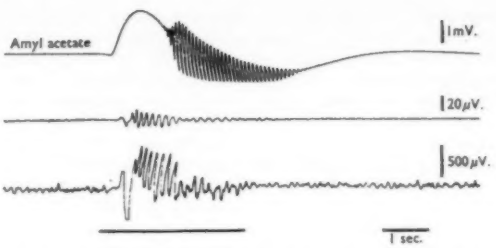

Fig. 1. Two types of potential oscillations. Top, a potential oscillation appearing on the falling phase of the slow potential; middle, a potential oscillation recorded in the olfactory nerve; bottom, a potential oscillation recorded in the olfactory bulb. It is noted that the first half of the potential in the olfactory bulb is identical in frequency, phase and shape with the one in the olfactory nerve, but is entirely different from the one in the olfactory epithelium. The horizontal line on the left below indicates olfactory stimulation

ones. Besides, it always began to appear some time after the beginning of the latter ones. It often appeared even after the latter ones had nearly disappeared, when stimulation was very short. In these points, the potential oscillation in the olfactory epithelium of the toad entirely differs from those in the olfactory nerve and bulb. The former oscillation closely resembles the rhythmic wave found by Ottoson[4] in the olfactory epithelium of the frog (*Rana temporaria*). Though we could not find the similar wave in the frog (*Rana nigromaculata*), it is supposed that the rhythmic wave found in *Rana temporaria* is identical to that in the olfactory epithelium of the toad. From these findings in the toad, it is concluded that there are two kinds of potential oscillations in the lower olfactory nervous system, and that they are mutually of indifferent origin and nature.

Full details of this work will be published elsewhere.

S. F. Takagi
T. Shibuya

Department of Physiology,
School of Medicine,
Gunma University,
Maebashi, Japan.
Dec. 22.

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Saliva–Serum Ratios of Tritium after the Administration of Tritiated Water

Taggart and Hytten[1] reported results which indicated that the salivary glands can concentrate deuterium oxide above the level in serum of human subjects. They had administered deuterium oxide orally to normal pregnant women and found, 3 hr. later, saliva–serum ratios ranging from 1·05 to 1·34, and in one subject after 24 hr. they found a ratio of 1·39.

These results have considerable importance as they suggest that human salivary glands can differentiate between deuterium and hydrogen, and it would therefore be of interest to know if a similar effect occurs with tritium. In view of the paucity of

information readily available[2] on this subject we decided to estimate the saliva–serum ratios of tritium 3 hr. after the administration of tritiated water in human subjects. The test was performed on 6 physically healthy subjects. 10 ml. of tritiated water containing 500 μc. tritium were given orally immediately before breakfast. 3 hr. later, samples of venous blood and saliva were collected. Water was obtained from serum and saliva by the technique described by Cooper *et al.*[3] and the tritium was estimated in a liquid scintillation counter.

Table 1

Sex	Age	Saliva water (c.p.s.)	Serum water (c.p.s.)	Ratio saliva–serum
F	38	68·6	68·0	1·01
F	45	67·7	67·5	1·00
F	35	54·4	55·6	0·98
M	32	53·8	52·6	1·02
M	36	63·5	64·2	0·99
M	34	59·5	59·3	1·00
Mean		61·25	61·20	1·00

Table 1 shows the results. The saliva–serum ratio at 3 hr. ranged from 0·98 to 1·02 with a mean of 1·00. Thus 3 hr. after its oral administration the tritium in the salivary gland has reached equilibrium with the water in the serum and there is no evidence that the salivary gland is able to concentrate tritium. If the differential concentration of deuterium oxide is related to the atomic weight of deuterium it would seem that this effect should be at least as equally marked with tritium.

Taggart and Hytten raised the possibility that some substance in saliva had distilled across with the water and affected the density of the distillate and thus the estimation of deuterium oxide by the falling drop method. In view of our findings, therefore, it would be useful to have the results of saliva–serum ratios of deuterium oxide estimated by mass spectrometry.

A. J. Coppen
J. L. Gibbons

Institute of Psychiatry,
Maudsley Hospital,
Denmark Hill,
London, S.E.5.

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Effect of Thyroxine and 2,4-Dinitrophenol on Levels of Ubiquinone and Ubichromenol in the Rat

The observation by Aiyar *et al.*[1] that thyrotoxicosis in the rat is accompanied by an increase in liver ubiquinone prompts us to record our own related findings. We have investigated the effect of thyroxine and 2,4-dinitrophenol on both ubiquinone and ubichromenol-levels in the rat, using animals from a stock colony and also from a vitamin-E deficient colony. Female rats were used, aged 3–4 months in one experiment and aged 15 months in another. The animals were divided into groups of six, and test groups received thyroxine, thyroxine and α-tocopheryl acetate, or 2,4-dinitrophenol. After three weeks on test, the rats were killed, and their hearts and livers (each organ pooled with others from the same group) were analysed for ubiquinone and ubichromenol by the method of Diplock *et al.*[2].

Table 1. Female Rats of the Norwegian Hooded Strain were used in Groups of Six

In Exp. 1, the rats were 3–4 months old; in Exp. 2, 15 months old. The supplements were: Exp. 1, thyroxine, 2,4-dinitrophenol and α-tocopheryl acetate all at 25 μgm./gm. of diet; Exp. 2, thyroxine 5 mgm. and 2,4-dinitrophenol 1·25 mgm. divided into bi-weekly doses intraperitoneally

Exp.	Group treatment	Ubiquinone (μgm./gm.)		Ubichromenol (μgm./gm.)	
		Heart	Liver	Heart	Liver
1	Adequate vit. E control	205	127	4·4	80·6
	Adequate vit. E + thyroxine	179	342	8·4	119
	E-def. control	149	162	4·0	46·8
	E-def. + thyroxine	180	227	9·4	83·0
	E-def. + thyroxine + α-tocopheryl acetate	199	235	9·9	82·0
	E-def. + 2,4-dinitrophenol	241	182	25·5	69·5
2	E.-def. control	159	96	15·7	34·1
	E-def. + thyroxine	141	482	14·3	148
	E-def. + 2,4-dinitrophenol	143	114	14·4	47·4

The results are given in Table 1, the figures for ubiquinone and ubichromenol representing the total isoprenologue content[3] in each case.

In both rats receiving adequate vitamin E and those deficient in this vitamin, thyroxine produced large increases in the ubiquinone- and ubichromenol-levels in the liver, these increases being particularly marked in the older group of vitamin-E deficient rats. Indeed, the levels in the livers of the latter animals are considerably higher than any others so far observed by us in the course of several hundred tissue analyses. The effects of thyroxine on levels in the heart were less marked generally. The further supplementation of the thyroxine group with α-tocopheryl acetate produced no noticeable effects in these experiments. When 2,4-dinitrophenol was given to vitamin-E deficient rats in an amount equivalent to thyroxine on a molecular basis, little effect was observed; but, when larger, nearly toxic doses of 2,4-dinitrophenol were given, a sharp increase in ubiquinone and ubichromenol occurred in the heart, although the liver was relatively unaffected.

Although 2,4-dinitrophenol and thyroxine are both agents that uncouple oxidative phosphorylation, their mode of action is different. It is possible that the above effects on ubiquinone- and ubichromenol-levels *in vivo* may be related to this uncoupling activity and that the differences observed may reflect the difference in mode of action; alternatively, they may be caused simply by a differing uptake of thyroxine and 2,4-dinitrophenol by the heart and the liver. Whether the increases in ubiquinone and ubichromenol are due to enhanced synthesis or to less-efficient utilization of these lipids cannot be deduced from these experiments, but the results here are qualitatively different from those of other experiments on the specific influence of vitamin-E on the levels of ubiquinone in the rat, in which a direct effect on synthesis is more clearly indicated.

E. E. Edwin
J. Green
A. T. Diplock
J. Bunyan

Walton Oaks Experimental Station,
Research Laboratories of Vitamins, Ltd.,
Dorking Road,
Tadworth, Surrey.

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Influence of Temperature upon Blood Coagulation in a Cold- and a Warm-blooded Animal

The influence of change of temperature upon the speed of blood clotting in warm-blooded animals is well recognized. Indeed, the fact that human plasma at 0° C. does not clot for several hours is utilized in some investigations in coagulation research.

If a similar depression of blood coagulation at low temperatures occurred in cold-blooded animals this would tend to make them unusually vulnerable to trauma during some part of their lives. This consideration led us to compare the influence of temperature on the clotting mechanism of a warm- and a cold-blooded animal.

Because of its ready availability, human blood was compared with that of the South African clawed toad *Xenopus laevis*. Human blood was collected by venepuncture and toad blood was obtained from the heart after the animal had been anæsthetized with ether. Considerable difficulty was at first experienced in obtaining adequate unclotted samples by methods involving direct cardiac puncture. To overcome this, the heart was exposed by a central skin excision, division of the pectoral girdle and opening of the pericardium. The animal was then placed on a wire netting (approximately 1 cm.² network) with the heart dependent between the wires. In this way approximately 3 ml. could be collected into an underlying vessel within a few seconds of a deep scalpel incision into the ventricle. The contamination by tissue juices, although present, is probably minimal under these conditions and the sample appears preferable to that obtained after a lengthy and technically difficult cardiac puncture technique. The blood from three toads was pooled to make a single specimen.

All samples were collected in graduated siliconed centrifuge tubes with 3·8 per cent of sodium citrate in a proportion of nine parts of blood to one part of citrate solution.

The thromboplastin preparations were made from emulsified human brain and emulsified toad brain and spinal cord. The dilutions were adjusted to give a satisfactory one-stage prothrombin time with human and toad plasma respectively. The thromboplastin time (one-stage 'prothrombin' time) and the calcium clotting time estimations were performed as recommended by Biggs and Macfarlane[1], but in the latter test citrated whole blood was substituted for citrated plasma.

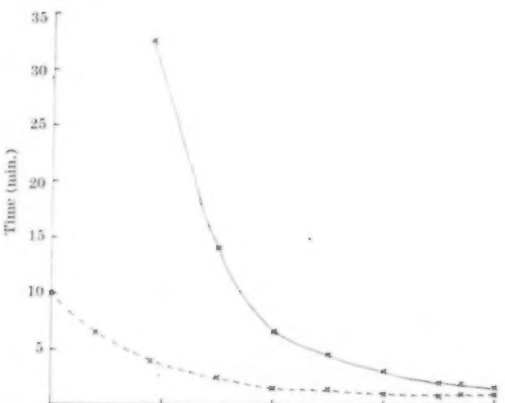

Fig. 1. The calcium clotting time (whole blood). ——, human; – – –, toad

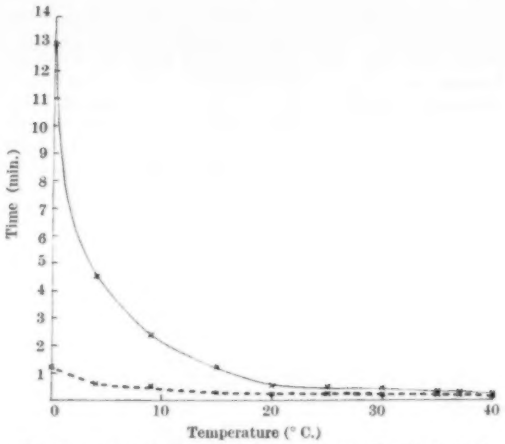

Fig. 2. Thromboplastin time (one-stage 'prothrombin' time). ——, human; – – –, toad

The results are shown in Figs. 1 and 2.

A determination of calcium clotting time was used in preference to one of whole-blood clotting time, because the latter would have required several fresh samples of blood, needing more than a single animal to cover the complete range of temperature being investigated. It therefore appeared desirable to test the clotting time of a single pooled citrated sample obtained from three animals after recalcifying at various temperatures.

In order to keep the platelet activity of the specimens as close to physiological conditions as possible, citrated whole blood rather than plasma was used in the estimations of the clotting time.

Quick[2] showed that tissue thromboplastin of a reptile (turtle) showed species specificity, when mixed with the plasma of warm-blooded animals. This specificity has been demonstrated with the amphibian used in this investigation. The thromboplastin times of human or toad plasma were therefore compared using human and toad brain emulsions respectively. Owing to the small size of the toad brain, the spinal cord was also included in the preparations.

From a comparison of the two curves in Fig. 1 it can be seen that the toad-clotting mechanism appears well adapted for functioning at low temperatures. Fig. 2 shows the influence of temperature on the thromboplastin time, which does not involve certain clotting factors, such as hæmophilic globulin, which are needed for active intrinsic thromboplastin formation. As with the recalcified whole blood clotting time the thromboplastin time in the cold-blooded animal appears comparatively unaffected by a temperature lowered below 10° C.

H. B. Anstall
Massachusetts General Hospital,
Boston, Massachusetts.

R. G. Huntsman
Department of Clinical Pathology,
Guy's Hospital, London, S.E.1.

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Blood Glucose in Crayfishes in Relation to Moult and Handling

DURING a recent investigation of the physiology of excretion in the crayfish[1], it was discovered that significant differences in blood glucose-levels existed between intermoult (stage *C*) and premoult (stage *D*) specimens of *Pacifastacus leniusculus* (Dana) (Table 1). The moult stage was determined by a modification of the method of Drach[2]. The crayfishes were kept in a water-bath at 16° C. in which they had been unsegregated and unfed for periods of one to two weeks. Blood glucose was determined by the glucose oxidase (enzymatic) method of Saifer and Gerstenfeld[3] (for details of experimental procedure, see Riegel and Kirschner, ref. 1).

Table 1. BLOOD GLUCOSE-LEVELS OF INTERMOULT (*C*) AND PREMOULT (*D*) MALE *Pacifastacus leniusculus*. DIFFERENCES ARE STATISTICALLY VERY SIGNIFICANT ($t = 3{\cdot}06$; $P = < 1$ PER CENT)

Moult stage	*C*	*D*
Number	10	9
Average blood glucose (mgm. per cent)	21	48
Range	(5–39)	(18–91)
Standard error	3·3	7·7

Glucose proved to be a highly mobile substance in crayfish blood; injected glucose disappeared rapidly. Handling of crayfishes (for example, injection of materials, and especially withdrawal of blood samples at frequent intervals) commonly resulted in a spontaneous rise in blood glucose-levels, a prolonged cessation or marked decrease in urine production, and in many cases the abnormal appearance of glucose in the urine.

The results of determinations of normal blood glucose-levels of *C*- and *D*-stage crayfishes agree with those of Renaud[4], who measured the reducing value of the blood of *Cancer pagurus*. However, Scheer[5] found no difference in blood carbohydrate-level between late *C*- and early *D*-stage *Carcinides* (= *Carcinus*) *maenas*. Similarly, McWhinnie and Scheer[6] found that the blood glucose-levels of *Hemigrapsus nudus* reached their maximum during the intermoult (*C*) stage of the moult-cycle and actually declined during the premoult (*D*) stage. McWhinnie and Scheer determined glucose by a method similar in most respects to that used in the present work. They found that glucose comprised less than 20 per cent of the total 'blood sugar' value determined by other less-specific methods.

The reasons for the spontaneous rise in blood glucose of handled crayfishes are obscure. It seems reasonable to assume that handling placed the crayfishes under stress. Since an elevation of blood glucose-levels is a common stress phenomenon seen in vertebrates, it is possible that a similar stress–blood glucose relationship exists in the crayfish. This explanation would fail, if the view of Scheer[7], that glucose is not utilized as a substrate for oxidative metabolism in Crustacea, is accepted. However, more recent evidence (ref. 8 and Scheer, B. T., personal communication) indicates that glucose is, in fact, utilized for oxidative metabolism in crustaceans; at least, according to Scheer[7], in those crustaceans that undergo a period of dormancy during their moult cycle (anecdysis). The crayfish is an anecdytic form, as are the crabs, *Hemigrapsus nudus* and *Carcinides maenas*.

The complete cessation or marked decrease in urine production and the glucosuria of crayfishes that were handled[1] is suggestive of a hormonal effect. For example, the stoppage or decrease in urine production commonly was maintained for 20 hr. or more during the experimental periods—long after handling had ceased. Further, it was only after 20 hr. that glucosuria occurred. It is well known that the sinus glands of Crustacea contain a diabetogenic hormone, which is reported to be responsible for most of the hyperglycæmic effects seen in those animals[9]. The diabetogenic hormone conceivably could be responsible for the hyperglycæmia and possibly the glucosuria of handled crayfishes. Further, it is possible that it, or some as yet unknown hormone fraction, has an antidiuretic effect in the crayfish.

This work was supported by funds provided for medical and biological research by the State of Washington Initiative No. 171, and by a grant (*G*4925) to L. B. Kirschner from the National Science Foundation.

J. A. RIEGEL*

Department of Zoology,
Washington State University,
Pullman, Washington.

* Postdoctoral Research Fellow of the National Heart Institute, National Institutes of Health.

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Membrane Potential Changes associated with Stimulation of Smooth Muscle by Adrenalin

THE smooth muscle of the taenia coli of the guinea pig is contracted by acetylcholine and is relaxed by adrenalin. It has been shown that acetylcholine contraction is associated with depolarization of the muscle membrane and initiation or increase in spike activity[1,2]. Adrenalin relaxation is associated with hyperpolarization of the membrane and inhibition of spike activity[1,3].

The smooth muscle of the muscularis mucosæ (dog) is contracted by both acetylcholine and adrenalin[4]. It was of interest, therefore, to observe whether adrenalin contraction of this muscle was associated with hyperpolarization or depolarization.

Membrane potential changes of muscularis mucosæ (pig œsophagus) in the presence of adrenalin and acetylcholine were measured by the sucrose gap technique[5]. Fig. 1 shows that contraction by adrenalin as well as by acetylcholine was associated with depolarization and initiation of spike activity.

This result supports the view that drugs act via a membrane system, where depolarization and initiation of spike activity result in contraction, and hyperpolarization in relaxation. It is unlikely that adrenalin acts in two completely different ways on the muscle membranes of the taenia coli and muscularis mucosæ. It is more likely that adrenalin acts in the same way on two muscles which differ in internal/external ion distribution and/or in membrane permeability properties. Comparison of the morphological features

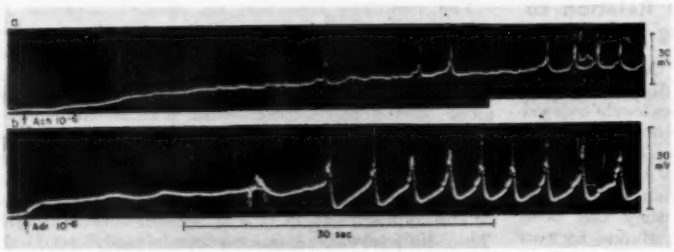

Fig. 1 Membrane potential changes and spike activity in the presence of: (*a*) acetylcholine (Ach) 10^{-6}; (*b*) adrenalin (Adr) 10^{-6}. Pig œsophagus muscularis mucosæ. Sucrose gap technique. Temp., 35° C.

and electrical properties of these two muscles revealed no qualitative differences[6,7]. Experiments designed to detect differences in ion distribution, permeability and electrogenic sodium pump activity[8] are in progress.

Some of this work was done in the Department of Physiology, University of Illinois.

G. Burnstock

Department of Zoology,
University of Melbourne.

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Accumulation of Substrate by Isolated Rat Diaphragm: a Possible Mechanism for the Anti-Inflammatory Action of Corticosteroids

Adrenalectomy enhances, and adrenal cortical hormone depresses, the incorporation of carbon-14 from amino-acids, and from amino-acid precursors, into the protein of isolated rat diaphragm[1,2]. These changes are, at least in part, the result of a direct effect on protein biosynthesis[1,3]. Whether corticosteroids also effect protein synthesis indirectly by influencing amino-acid transport and accumulation is not known. The possibility was tested by measuring the penetration and accumulation of [1-^{14}C-]-amino*iso*butyric acid[4], a non-utilizable amino-acid analogue, and of the utilizable amino-acids [U-^{14}C] L-phenylalanine and [U-^{14}C] L-lysine, by 'intact' diaphragms[5] isolated from normal, adrenalectomized, and cortisone-treated rats.

Table 1. Effect of Adrenalectomy and Cortisone on the Accumulation of Carbon-14 Labelled Substrate by Isolated 'Intact' Rat Diaphragm

Substrate added to the medium	Counts/min./ml. intracellular water / Counts/min./ml. incubation medium		
	Normal	Adrenal-ectomized	Cortisone
[1-^{14}C]-amino*iso*-butyric acid	1·41 ± 0·061 (6)*	1·35 ± 0·046 (6)	0·72 ± 0·021 (6) ($P < 0·001$)
[U-^{14}C]-L-phenyl-alanine	2·51 ± 0·120 (6)	2·41 ± 0·149 (6)	1·79 ± 0·052 (6) ($P < 0·001$)
[U-^{14}C]-L-lysine	1·95 ± 0·059 (6)	1·88 ± 0·055 (6)	0·92 ± 0·030 (6) ($P < 0·001$)
[2-Ring-^{14}C] histamine dihydro-chloride	3·88 ± 0·125 (6)	3·69 ± 0·375 (6)	2·83 ± 0·096 (6) ($P < 0·001$)

Diaphragms from normal, adrenalectomized (4 days) and cortisone-treated (2 mgm./day for 4 days) rats were incubated with shaking for 2 hr. at 37° in 5 ml. Krebs–Henseleit bicarbonate buffer. Concentration of substances used were: [1-^{14}C]-amino*iso*butyric acid, $1·37 \times 10^{-4}$ *M*; L-phenylalanine, $4·9 \times 10^{-4}$ *M*; L-lysine, $6·55 \times 10^{-4}$ *M*; histamine, 1×10^{-4} *M*. The radioactivity added was, in each experiment, 0·5 μc./ml. Accumulation of soluble radioactivity was determined by extracting diaphragm with 10 ml. of 1 per cent trichloracetic acid at 100° for 5 min. Aliquots of the soluble extract and of the incubation medium were diluted, plated and assayed with a gas-flow Geiger counter. The results are expressed as the ratio of counts/min./ml. intracellular water (assumed to be 75 per cent of wet weight) to counts/min./ml. incubation medium; a ratio greater than one indicates intracellular concentration against a gradient. The value of *P* for a difference which is significant is given in brackets.

* Mean ± *S.E.* of mean; number of observations in parenthesis.

Cortisone significantly depressed accumulation in skeletal muscle of [1-^{14}C]-amino*iso*butyric acid and of L-phenylalanine and L-lysine; adrenalectomy was without effect on this process (Table 1). It is concluded that increased protein biosynthesis after adrenalectomy is not due to stimulation of amino-acid penetration; decreased accumulation could contribute to the depression in protein synthesis after cortisone.

The decrease in amino-acid penetration after cortisone has another and possibly more important implication, namely, that the mechanism of corticosteroid protection against inflammation and allergy may involve exclusion from cells of inciting humoral substances, similar in structure to the amino-acids, as for example histamine. This possibility was tested. Cortisone decreased accumulation of carbon-14 histamine by isolated muscle (Table 1). The biochemical basis of the anti-inflammatory and anti-allergic action of corticosteroids may be a decrease in the penetration into cells of a local humoral substance (histamine or like histamine) which in turn serves as the stimulus for tissue changes in inflammation and allergy.

This investigation was aided in part by a grant (*A*–1653) from the National Institutes of Health, and by the Wallace C. and Clara A. Abbott Memorial Fund of the University of Chicago.

Ira G. Wool

Department of Physiology,
University of Chicago.

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IMMUNOLOGY

A Possible Basis for Immunological Tolerance

The following hypothesis is based on the possibility that, although the mechanism for the entrance of macromolecules into the cell may be the relatively non-specific phenomenon of pinocytosis, the mechanisms for secreting materials out of the cell may be specific. These unknown (probably active) transport mechanisms will, for ease in referring to them, be called 'secretases', by analogy to the bacterial permeases, which are concerned with entry rather than exit mechanisms[1]. Simple diffusion would account for only a small part of the macromolecular

traffic in either direction across the membrane, since most of the 'pores' or holes in the cell membrane would be too small to allow passage of the large protein molecules.

The very young or embryonic animal is generally incapable of giving an immune response or forming antibodies; at what particular stage it does acquire the ability to respond depends upon the species of animal. The degree of relationship of the antigen to native components of the animal may also be important. In the developing animal the cells of the future globulin- and antibody-synthesizing system are in the process of rapid division and differentiation. In some unknown manner cells acquire the ability to produce globulins of many different configurations. It is suggested here that a mechanism (the 'secretase') is induced in these cells to secrete the synthesized serum protein into the serum. Secretases would also be induced to act on the materials produced by the other cells, and brought into any given cell by non-selective processes.

The number of different secretases need not be impossibly large; there may well be, for example, a few relatively unchanging regions common to many different globulin molecules. Other regions of the globulin molecules would be more variable[2] and would account for the many different antibody specificities. Porter[3] has evidence that the γ-globulin molecule consists of three parts: fraction III is apparently identical in all gamma-globulin molecules, and fractions I and II contain the antibody-combining sites. The types of secretases inducible would be under genetic control, and only those secretases for which there were genetic information available would be inducible. The inducibility of un-induced secretases would be lost or inhibited in the mature animal, although the fact that X-irradiation[4] or treatment with 6-mercaptopurine[5] can restore the ability to acquire tolerance suggests that this type of differentiation is not irreversible for the organism as a whole.

According to this hypothesis, antigen injected into the normal animal would be collected in cells by non-specific mechanisms, and, not being able to get out, would be metabolized. Humphrey[6] has suggested that foreign materials in the circulation are removed from the tissue fluids by the mechanisms that deal with similar native materials. In those cells where molecules with a configuration complementary to the antigen (antibodies, usually γ-globulins) were being produced, combination between the two would occur intracellularly. The resulting complex would then be broken down, and the increase in metabolites might be the stimulus that causes these cells to grow, accelerate their production of antibodies, and proliferate. Talmage's observation[7] that the greater the binding of the antigen to the antibody, the greater the degree of stimulation of antibody synthesis, would be explained by a facilitated breakdown of the antigen–antibody complex in those cells where the affinity of the antigen for the antibody was strongest. Cinader and Pearce[8] observe that "the difference between the half life of H.A. [human albumin] in normal and in tolerant animals may indicate the possible existence of a specific process of elimination which acts before the final rapid elimination of antigen by antibody begins. This process may be abolished by injection of antigen immediately after birth".

Presence of the antigen during the critical induction period would result in the induction of a secretase for the antigen, if the genetic information were available. Continued presence of the antigen in the tissues would be required to maintain the secretase; if antigen were lost from the tissues the secretase would gradually be diluted out and the animal would lose its tolerance. The tolerant animal could not form antibody against the tolerated antigen, or against its own serum proteins, because the secretase would prevent these molecules from accumulating in the cells in amount sufficient to stimulate detectable antibody production.

Humphrey[6] has shown that in at least one case homologous protein persists intact within katabolizing cells for only a very short period of time. One might predict, on the basis of this hypothesis, that antigen would be eliminated from the *serum* of non-tolerant animals, prior to their immune response, at a faster rate than it would be eliminated from the serum of tolerant animals. Cinader and Pearce[8] found that non-tolerant animals could eliminate antigen from the serum at a faster rate than tolerant animals; however, work by Denhardt and Owen[9] with a small number of rabbits indicated that tolerant animals could eliminate antigen from their sera at a greater rate than non-tolerant animals. Further study of this problem is highly desirable.

In conclusion, it is realized that tolerance may be equally well accounted for in terms of induction of a specific enzyme katabolizing the antigen; perhaps what is required is a synthesis of these two points of view. The 'secretase' may be considered as the hypothetical 'recognition unit' postulated by Burnet and Fenner[10].

The encouragement and expert guidance of Dr. Ray Owen and the helpful suggestions of Prof. Peter Medawar are gratefully acknowledged.

D. T. Denhardt

Swarthmore College,
Swarthmore, Pennsylvania.

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HÆMATOLOGY

A New Electrophoretic Medium and its Application to the Resolution of Human Hæmoglobin Variants

Several techniques for the analysis of protein mixtures by either zone electrophoresis on inert media[1] or chromatography on ion-exchange cellulose derivatives have been described[2,3]. Greater scope and versatility should result if the supporting medium used for zone electrophoresis itself ionizes. In standard gel-electrophoresis techniques, ion transport takes place almost exclusively through the interstitial solution. The incorporation of ion-exchange groups into a gel superimposes a selectivity effect, the migration of the ions being retarded to a varying extent depending on their affinity for the exchanger. Attempts to use ion-exchange cellulose papers in

this way have so far been unsuccessful. It is, however, also possible to prepare these cellulose derivatives in gel form. Electrophoresis on such a continuous-phase ion-exchange medium has not been reported hitherto. This communication is a preliminary report on the combination of electrophoretic and ion-exchange techniques applied to the separation of human hæmoglobin variants, using carboxymethyl cellulose gel as the supporting medium.

The sodium counter-ion form of the weakly acidic cation exchanger, carboxymethyl cellulose, is soluble in water at degrees of substitution above about 0·3, while below 0·15 the exchanger is fibrous though swollen. Between these limits it is in gel form, and by suitably modifying the standard preparative technique a range of gels can be made (Jakubovic, A. O., unpublished results). Certain aspects of the fibrous exchanger have been described[1,5], and it has also been applied to the chromatographic separation of hæmoglobins by Huisman and his colleagues[3].

One batch of gel (supplied by W. and R. Balston, Ltd.), carboxymethyl cellulose of 0·18 substitution, having a cation-exchange capacity of 1·05 m.equiv./gm. dry, and swollen to 90 per cent water content, was used throughout the experiments. After purification by dialysis in de-ionized water, the gel was dialysed with the appropriate buffer—sodium phosphate of 0·17–0·04 *M* sodium ion concentration—and placed in a suitable 'Perspex' boat. The final *p*H in the gel was 6·7. Electrophoresis was carried out overnight. The naturally occurring hæmoglobin combinations used in the experiments described were hæmoglobins A, SC, AS, AF (thalassæmia major, HbF = 75 per cent) and AJ.

The hæmoglobins invariably migrated to the cathode, the rate of migration increasing with the sodium ion concentration. At the highest concentrations used, the hæmoglobins moved through the gel rapidly, showing only slight separation (Fig. 1*a*). On lowering the sodium concentration they moved more slowly, migrating at various rates, but always in the order hæmoglobin A followed by hæmoglobin S and F close together and then C; at the lowest sodium concentration used they remained close to the origin (Fig. 1*b*). By varying the sodium ion concentration, either the hæmoglobin S to C or the hæmoglobin A to S gap could be magnified (Fig. 2*a* and *b*). The best overall separation was achieved with a sodium ion concentration of 0·07 *M* (Fig. 2*c*). This figure also shows clear separation of hæmoglobin A from F.

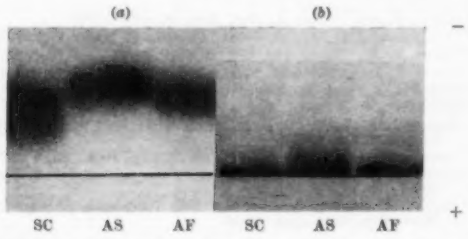

Fig. 1. Electrophoresis of human hæmoglobin variants on carboxymethyl cellulose gel at the extremes of sodium concentrations used: (*a*) 0·17 *M*; (*b*) 0·04 *M*

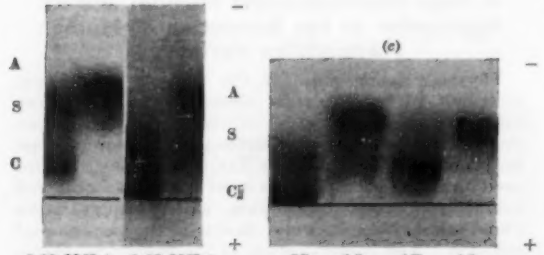

Fig. 2. Electrophoresis of human hæmoglobin variants on carboxymethyl cellulose gel. (*a* and *b*) Effect of variation of the sodium ion concentration on the separation of hæmoglobins A, S and C. (*c*) Overall separation achieved at 0·07 *M* sodium concentration, including separation of hæmoglobins A and F

Table 1

Starch-gel electrophoresis (sodium phosphate *p*H 6·8)*	Carboxymethyl cellulose gel electrophoresis (*p*H 6·7)	Carboxymethyl cellulose chromatography (*p*H 7–8) (ref. 3)
In sequence of increasing migration to the cathode		In order of retention on column
HbJ	HbC	HbC
HbA, HbF, HbS, HbC — close together	HbS, HbF — very close together; HbA and J	HbS
		HbF
		HbA
		HbJ

* Huehns, E. R., Flynn, F. V., Butler, E. A., and Shooter, E. M. (unpublished work).

In Table 1 the order of migration in starch-gel electrophoresis, carboxymethyl cellulose gel electrophoresis and chromatographic elution from fibrous carboxymethyl cellulose are compared. Under the carboxymethyl cellulose gel electrophoretic conditions used, the ion-exchange effect was predominant. From Table 1 it can be seen that hæmoglobins C, S and F are strongly held by the gel, but in the case of hæmoglobin J the ion-exchange and electrophoretic effects seem to be balanced and therefore hæmoglobins A and J did not separate.

It would, however, be possible to change the *p*H of electrophoresis in such a way that the charge on the protein was reversed, and the migration would then be unaffected by the exchange groups of the gel. The influence of the latter depends on the concentration and ionization of the carboxyl groups. The concentration can be varied by changes in degree of substitution of the cellulose and swelling, the ionization by varying the *p*H and ionic concentration of the ambient electrolyte. Only the last has been utilized here. The effect of varying the capacity and swelling of the exchanger gel and the *p*H of electrophoresis, as well as the wider utilization of this new method of gel-phase ion-exchange electrophoresis, is being investigated.

We wish to thank Dr. E. M. Shooter for helpful advice and discussion. The work was carried out during the tenure by one of us (E. R. H.) of a Beit Memorial Fellowship.

E. R. Huehns

Department of Biochemistry, University College, London.

A. O. Jakubovic

Whatman Research Laboratory, W. and R. Balston, Ltd., Maidstone, Kent.

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PATHOLOGY

Chronic Aortitis in the California Sea-lion, *Zalophus californianus*

During a long-term study on the general biology of the California sea-lion, *Zalophus californianus* (Lesson), it became evident that degenerative diseases associated with ageing are very common in this species. Therefore, a study of the heart and aorta was undertaken.

Circulatory disease in captive pinnipeds has been extensively studied by Fox[1] over a number of years. His findings included arteriosclerosis with typical medial involvement as well as myocarditis. Of the ten pathological specimens he found during this work, no indication was given of the genus and species involved; all animals were grouped under the order Pinnipedia.

The present study deals with lesions in the aorta of three mature bull sea-lions and is the first report of such pathology in this species to be found in a wild population. The hearts of seventy animals of both sexes were taken at random for study from a total collection of some two hundred specimens; these were obtained over the past two and a half years from islands off the coast of Baja California, Mexico. The collection area ranged from Los Coronados Islands (lat., 32° 26′ N.; long., 117° 16′ W.) to Cabo San Lucas, the extreme southern tip of Baja California (lat. 22° 45′ N.; long. 110° 00′ W.). All three of the abnormal individuals were secured on Los Coronados Islands, where most of the males were collected.

As soon as possible after killing, the hearts were removed leaving several inches of aorta attached: after rinsing in water, the tissue was preserved in 10 per cent formalin for later examination. The aortas were screened for visible lesions. Of the three specimens exhibiting gross pathology, two were sent to two separate laboratories for section and independent histopathological study; the third was retained and examined by us. The three diagnoses were identical. The sections were stained with hæmatoxylin and eosin. No gross myocardial disease was evident in any case.

Using the Lieberman–Burchard reaction on ether extracts of the finely ground material, samples from the pathological areas revealed a considerably higher cholesterol content than samples of the tissue from apparently normal adjacent regions.

Grossly, the intimal surface of the arteries contained numerous punctate elevations which, in the most extreme case, resembled tree bark. Approximately 10 per cent of the intimal surface was involved and the affected areas ranged in width from 0·1 to 1·5 cm.

Microscopically, the sections of aorta revealed extensive active aortitis, while other areas showed healing. The intima itself was not involved; rather there was, in the foci of the active areas, an extensive inflammatory reaction in the media, extending from the subintima to the adventitia. The disease process involved destruction of elastic tissue about the blood vessels and an infiltration of plasma cells, macrophages and lymphocytes. A secondary fibrosis in the subintimal areas overlaid the zones of aortitis. The healed areas contained abnormally large blood vessels surrounded by small amounts of scar tissue.

In many respects the condition found in these sea-lions resembles the aortic lesions found in chronic human syphilis, although the etiology of the disease in these animals is unknown.

The work was accomplished while the senior author served as a research assistant of the Institute of Marine Resources at the University of California and while the junior author held a fellowship-grant from the San Diego County Heart Association, to which grateful acknowledgment is made. The work was made possible by the effective co-operation of the Mexican Government.

Our sincere thanks are due to Dr. Lewis A. Palmer, La Jolla Clinical Laboratory, and Dr. Findlay E. Russell, College of Medical Evangelists, Los Angeles, for their kindness in the preparation and diagnosis of the sections.

Arthur L. Kelly
David Jensen
Scripps Institution of Oceanography,
La Jolla,
California.

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BIOLOGY

Inactivation by Visible Light of Yeast sensitized by a Nucleic Acid Fluorochrome

Precise and reproducible survival curves have previously been obtained for haploid and diploid yeast irradiated with X-rays and with ultra-violet light[1,2]. Similar curves have now been obtained for the inactivation by visible light of yeast cells sensitized with the fluorescent diaminoacridine dye, acridine orange (3,6-*bis*-dimethylaminoacridine).

Cells of a haploid (*SC*–7) and a diploid (*SC*–6) strain of the yeast, *Saccharomyces cerevisiae*, were used in resting condition following seven days growth on potato dextrose agar at room temperature. Survival was measured by colony count on agar plates after three days incubation at 30° C. in the dark. The light source was a General Electric *R*–52 750-watt flood-lamp filtered to remove wave-lengths greater than 6000 Å. and less than 4100 Å.; the incident flux at the level of the samples was approximately 10^5 erg/cm.²/sec. 20 min. before irradiation, highly purified acridine orange was added to a suspension of 10^6 cells/ml. in *p*H 7 phosphate buffer to make a final dye concentration of 1 : 200,000 or $1{\cdot}8 \times 10^{-5}$ *M*. Details of the dye purification process and of experimental technique will be given elsewhere. All operations were performed under red light. Neither visible irradiation in the absence of dye nor the presence of dye without irradiation produced inactivation.

Typical visible light inactivation curves for haploid and diploid yeast are shown in Fig. 1. These curves exhibit high reproducibility except for the resistant 'tail' appearing at low diploid survival. (Such variable tails are also found for X-ray and ultra-violet inactivation.) These curves are similar to those obtained for ultra-violet inactivation[2] in that they are multi-component types of low 'hitness' and that the diploid is more resistant than the haploid.

These similarities between the visible and the ultra-violet inactivation curves tempt one to conclude that visible light inactivates some of the same

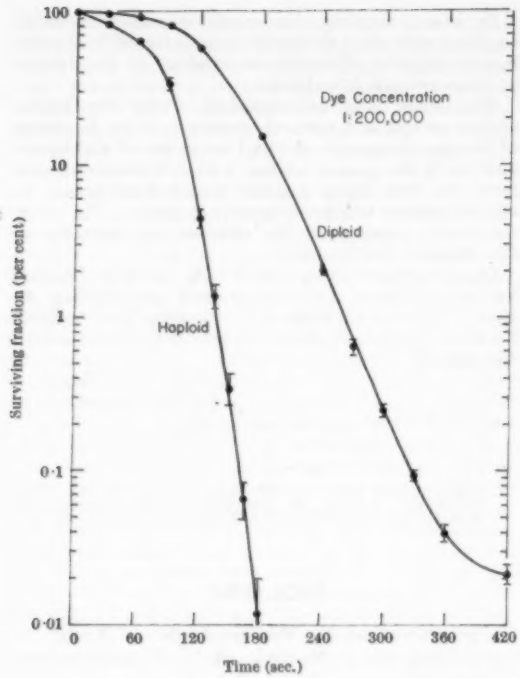

Fig. 1

sites that are sensitive to ultra-violet and that at least part of the damage can be explained by the replica diploid model[3,4] which has been invoked to account, in part, for the well-known difference in sensitivity between haploid and diploid yeast for ultra-violet and for X-rays. However, the equality of the limiting slopes of the haploid and diploid curves, which would be required if all the damage resulted from a replica diploid mechanism, is lacking. To examine further the nature of the visible light inactivation, perhaps the best approach (made feasible by the reproducibility of the survival curves) is that of additivity experiments in which doses of X-rays, ultra-violet and visible light are combined. From a series of such experiments, we have concluded that there is indeed considerable overlap among the targets and sites sensitive to these different radiations and that the difference in visible light sensitivity between the haploid and diploid strains can be explained, in part, on the basis of the replica diploid model. These experiments will be reported elsewhere.

These curves are of interest for several reasons. There has recently been much interest in the application of diaminoacridine dyes, particularly acridine orange, as stains in fluorescence microscopy[5]. These dyes allow one, on the basis of the different colours of the emitted light, to localize and distinguish structures containing ribonucleic and deoxyribonucleic acids within a cell. Most of this work has been done on fixed preparations with impure dye. Although the dyes will also stain the living cell, there are reports of deleterious effects on populations of micro-organisms and on cells in tissue culture[6–9]. It is likely, especially in view of the strong fluorescence of these dyes, that much of the damage reported in living preparations is caused by photodynamic action or other photoinactivation resulting from light absorbed by the bound dye, as is the case with the yeast inactivation reported above. Indeed, regeneration of liver tissue within the living rat has been shown to occur in the presence of proflavin[10]. It is then possible that under appropriate conditions these dyes can be used for non-injurious staining of many kinds of living cells. We have found that this is in fact the case for low concentrations of dye and that if suitable precautions are taken against the action of visible light (that is, by growing cultures in the dark and working by red light), such diverse materials as yeast, *Escherichia coli* and human liver cells in culture not only withstand exposure to acridine orange while in the resting state but also multiply indefinitely in concentrations of dye sufficient to permit observation of actively dividing cells with a sensitive fluorescence microscope (unpublished work).

By detailed analysis of inactivation curves, it may be possible to identify the specific intracellular sites to which the dye molecules are actually bound *in vivo*. Further, if most of the dye contained in the cell is bound specifically to nucleic acid and if the photodamage results from action upon these molecules alone, then there may be available a method for destroying part or all of a nucleic acid molecule without the concomitant effects upon protein which result when ultra-violet radiation is used for this purpose.

This investigation was aided by research grant *C*–2739 from the National Cancer Institute of the United States Public Health Service. One of us (D. F.) was supported by a National Science Foundation Predoctoral Fellowship.

David Freifelder*
Robert B. Uretz

Committee on Biophysics,
University of Chicago,
Chicago 37.

* Present address: Department of Biology, Massachusetts Institute of Technology.

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Pure Culture of the Trichomycete, *'Amoebidium parasiticum*

The Trichomycetes as defined by Duboscq *et al.*[1] include four orders of little-known fungi. Common characteristics of this class include a polarized thallus of limited growth, a basal holdfast, and association with various arthropods, usually as endocommensals in the digestive tract.

Previous work on the Trichomycetes has raised some interesting problems for both the botanist and zoologist. There are repeated suggestions in the literature that the resistant stages of the Trichomycetes are induced by host moulting. If this should

be the case, it immediately brings to mind the close relation existing between the wood-roach flagellates and their host during the moulting period[2]. Numerous questions on host specificity, host relations and nutrition await further investigation. A possible answer to some of these questions can be obtained through experimental approaches utilizing pure (axenic) cultures. Previous investigators have failed to isolate any member of the Trichomycetes in pure culture. Lichtwardt[3] and I (unpublished work), utilizing varied methods and conditions, failed to culture members of the Eccrinales.

The discovery of a large population of various *Cladocera* infected with *Amoebidium parasiticum* (see Fig. 1, left) has made possible cultural attempts with this Trichomycete. Heavily infected animals were dissected in sterile diluted pond water. This dissection resulted in the release of numerous endospores into the water. The endospores were retrieved with a fine capillary pipette and carried through three washes of sterile water. The spores were then transferred in a drop of water to dilute (0·1 per cent) tryptone agar plates and streaked with a sterile glass rod. Colonies of *Amoebidium parasiticum*, which were free from bacteria, were observed after three days (see Fig. 1*b*). They were then transferred to 1 ml. of water at the base of a tryptone agar slant and to a tryptone–glucose broth. Good growth occurred on both of these media and purity was maintained. (Composition of broth : 5 gm. tryptone, 3 gm. glucose per litre. Total phosphate, 0·003 *M* ; inorganic constituents as indicated by Machlis[4].)

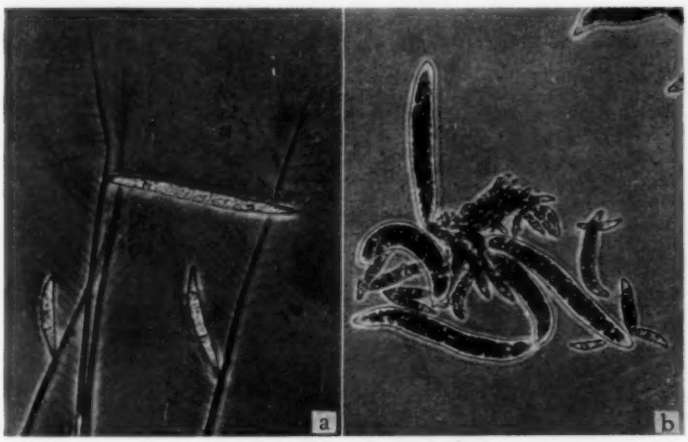

Fig. 1. (*a*) Thalli of *A. parasiticum* attached to plumose setæ of *Simocephalus* sp. (Cladocera). × 350. (*b*) Thalli of *A. parasiticum* grown in tryptone–glucose broth. × 170

Reproduction in pure culture is by endospores and factors causing amœba formation have not yet been determined. As *Amoebidium parasiticum* is usually an ectocommensal and exhibits a rather low host specificity it is perhaps not surprising that it was obtained in pure culture. The techniques utilized are fairly standard[5] and have been used by Emerson in culturing *Oedogoniomyces lymnaeae* and by me in culturing *Harpochytrium hedenii*. Both these fungi have unbranched thalli with basal holdfasts. However, their vegetative reproduction is by uniflagellate zoospores and they are not associated with animal hosts. It is believed that a comparative study using pure cultures of *Amoebidium*, *Oedogoniomyces* and *Harpochytrium* will yield information on the biology and relations of these interesting organisms.

HOWARD C. WHISLER

Department of Botany,
University of California.

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Furunculosis in Salmon Kelts

ACCORDING to the report of the Furunculosis Committee[1], this disease is most common among salmonids during the summer, when river-levels are low and when the water temperature lies within the range 55–66° F. The final report of this Committee[1] does, however, mention the occurrence of this disease in spawning or spawned salmon "in at least two districts in Scotland", but no further details are given.

Large numbers of salmon die in the rivers each year after spawning. The cause of this mortality, which is heavier among males than among females, is unknown, but it is commonly supposed to be the outcome of a period in fresh water without food and of the strain imposed by movement upstream followed by spawning.

During the autumn of 1958, salmon were impounded in the upper reaches of a Scottish river for stripping. Three of these fish died before stripping, and it was later found that they had died from furunculosis ; more of the fish died after stripping, again, as was afterwards learned, from furunculosis. These results suggested either that these fish had become infected during their period of impoundment or that furunculosis was a more common cause of death in kelts than had been supposed. To examine the latter possibility, dead or dying kelts were collected from the lower reaches of the river in question and from three other Scottish rivers. In all, 96 kelts were examined and, of these, 85 had furunculosis.

River-levels were very low during November and December 1958, and these unusual conditions may have contributed to this result, in that fish were more closely congregated than usual, offering favourable conditions for the spread of disease, and dead fish were more easily seen and removed. Observations on the occurrence of furunculosis in kelts were therefore again made in 1959. Most of the rivers were in spate during the spawning season of that year, so that recovery of dead kelts was more difficult. To date, 24 kelts have been received from 5 rivers, and 9 of the kelts had furunculosis. This incidence of furunculosis in kelts was not confined to Scottish rivers, as during 1959, 14 salmon kelts were examined in England and Wales. I am indebted to Mr. F. T. K. Pentelow, chief salmon and fresh-water fisheries officer, for the information that 11 of these were suffering from furunculosis.

Whether or not the incidence of furunculosis among kelts in the Scottish rivers in 1958 was unusually high, the two sets of results suggest that the normal incidence of this disease in kelts is high enough to warrant further investigation. As this might be an important factor in the spread of the disease, these observations will be continued.

Isabel W. Smith
Marine Laboratory (Department of Agriculture and Fisheries for Scotland), Aberdeen.

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Genetical and Biochemical Studies of the Immobilization Antigens of *Paramecium aurelia*

Highly purified preparations of the immobilization antigens of *Paramecium aurelia*, about which extensive genetic studies have been described previously[1], are now known to consist largely of protein (ref. 2 and unpublished work by J. O. B.). With the aim of obtaining information on genetically controlled protein variations, we have made a preliminary study of the physicochemical properties of some of these antigens, using various stocks of *P. aurelia* (variety 1). The antigens studied are denoted 60D, 90D, 103D, 33D, 60G, 60T. Formation of the first four is governed by a series of alleles denoted D^{60}, D^{90}, etc., and of the fifth by a non-allelic gene G^{60} in conjunction with a different cytoplasmic state. The type 60T is produced in conjunction with a third cytoplasmic state; but the genic basis of this type has not been investigated.

The immunological relationships between the different types of antigen appeared to vary according to the kind of test which was performed. By the immobilization test very little cross-reaction was found when any heterologous combination of the above-mentioned antigens and the various antisera was made. Other tests, however (absorption of immobilizing antibodies by whole *Paramecia* or migration of precipitin bands in agar-gel diffusion experiments), showed that the four D antigens are immunologically related to each other, and are unrelated to the 60G type (J. O. B., unpublished work).

Electrophoretic behaviour of the antigens was studied on starch-gel at *p*H 9·6 by a modification of the method of Smithies[4]. A gradient of 30–40 V. per cm. was found to be necessary to get appreciable movement of the antigens and the runs usually lasted 6–8 hr. After this time a slice of the gel was removed and stained with nigrosin, showing the presence of a single band of protein near the origin on the anode side. All other mobile proteins had passed into the anodic buffer vessel by this time. Correspondence of the stained band with antigen was shown by taking a parallel slice of gel and testing the eluate obtained from it for specific serum-blocking activity.

In this way the electrophoretic mobilities of the antigens were compared and it was found that type 60G moved toward the anode significantly more slowly than any of the D types (see Fig. 1), and type 60T was the fastest. All four (allelic) D types were apparently identical in mobility under these conditions.

Some of the antigens were also compared in regard to their adsorption–desorption behaviour on a column of calcium phosphate, using the technique of Tiselius *et al.*[5]. Partially purified preparations of various

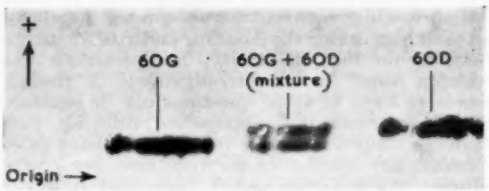

Fig. 1. Photograph of starch-gel slice containing three samples of antigen, stained with nigrosin after 4 hr. electrophoresis at 30 V. per cm., *p*H 9·6

antigens were applied to the column and elution was then carried out with phosphate buffer at *p*H 6·8, starting with an ionic strength of 0·001 *M* and increasing stepwise to 0·05 *M*. Protein in the samples of eluate was measured spectrophotometrically by ultra-violet absorption at 280 mμ and antigenic activity assayed by serum-blocking. It was found that antigen 60G was eluted by buffer at an ionic strength of 0·005 *M*, 60D and 60T at 0·01 *M* and 90D at 0·05 *M*. When two antigens (60D and 90D) were mixed together and chromatographed on calcium phosphate, two peaks of protein—each containing only one antigen—were obtained at positions on the elution diagram corresponding exactly to those found when the two antigens were chromatographed separately.

We therefore conclude that the electrophoretic comparisons of the different antigens studied to some extent parallel the immunological and genetical relationships: antigens which are unrelated immunologically and controlled by genes at different loci (for example, the G and D types) differ electrophoretically; antigens which are immunologically closely related and controlled by allelic genes at a single locus do not show electrophoretic differences under the conditions chosen, but do differ in regard to their adsorption–desorption behaviour on calcium phosphate.

More detailed accounts of the work referred to here will be published elsewhere. Thanks are due to the Medical Research Council for a grant supporting this work.

J. O. Bishop
G. H. Beale
Department of Animal Genetics, University of Edinburgh.

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BACTERIOLOGY

Mechanism of Immunity in Hæmorrhagic Septicæmia

Hæmorrhagic septicæmia of cattle and buffaloes caused by *Pasteurella multocida* type E kills many thousands of animals in Asia each year. It is possible to immunize against the disease effectively with improved vaccines, and in addition 5–10 per cent of animals possess a naturally acquired immunity. Both kinds of immune animals have in their sera circulating antibodies which are detectable by the passive mouse protection test. Hitherto, it has been

difficult to find whether these protective antibodies operated by a bactericidal or an opsonizing mechanism. Experiments using cultured bacteria, even those from primary plates sown with infected blood, showed no significant differences between known positive and negative sera in the bactericidal test of Muschel and Treffers[1], or in phagocytosis tests in roller tubes using heparinized or citrated blood.

Recent experiments in Australia and Thailand using pasteurellas grown *in vivo* in cattle and buffaloes give clear results in both bactericidal and phagocytosis tests. In 25 buffaloes and 6 cattle, complete correlation was obtained in mouse protection, serum bactericidal, opsonizing tests and direct challenge of the donor animals by subcutaneous injection of 1000 *LD* of the pasteurella. Twenty-six were positive to all tests and survived; five were negative to all tests and succumbed. In the latter group an occasional leucocyte was found containing a single pasteurella, whereas in the positives nearly every polymorphonuclear cell in the smears from roller tubes contained several pasteurellas. The bactericidal effect was measured by the ability of fresh sera in dilution of 1 ml. in 10 ml. broth to prolong the lag phase of the inoculum of pasteurellas introduced in 0·01 ml. infected serum. When growth occurred after the period of inhibition there was no agglutination except in the very strongly reacting sera. Mice inoculated with 0·1-ml. samples withdrawn 30 min. after the positive tests were set up survived, whereas those inoculated from negative tests died. This indicates a bactericidal effect on the inoculum rather than a temporary agglutinating action; the amount of serum in the inoculum was only one-tenth of a mouse protective dose in a conventional passive immunizing test. Parallel tests conducted with cultured pasteurellas were uniformly negative for bactericidal action, and phagocytosis was approximately equal in both immune and control bloods.

Extraction by 2·5 per cent aqueous solution of sodium chloride of dried cultivated pasteurellas yielded 0·5 per cent by weight of a ketose-containing polysaccharide which is disposed mostly at the surface of the small capsules. This substance was not detectable in pasteurellas grown *in vivo*[2]. This is the only difference known at present between the two kinds of bacteria which might account for their different reaction in the bactericidal tests.

R. V. S. Bain

Department of Veterinary Pathology,
University of Sydney.

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Nitrogen Fixation in Extracts of *Azotobacter vinelandii*

It is well established that soil micro-organisms, including species of *Azotobacter* and *Clostridia*, fix atmospheric nitrogen. Although several attempts have been made to demonstrate the incorporation of nitrogen-15 into extracts of these micro-organisms the results at best have been variable and of doubtful significance[1]. Protoplasts, prepared from *Azotobacter* by careful lysis of the cells with lysozyme, incorporated only small amounts of nitrogen-15, namely, an enrichment of 0·04 atom per cent excess[2]. We have recently succeeded in preparing cell-free extracts from *Azotobacter vinelandii*, either by treating the cells with lysozyme or with the ultrasonic probe, which will incorporate nitrogen-15 at a measurable rate. The cells must, however, be disrupted in the culture medium in which they were grown.

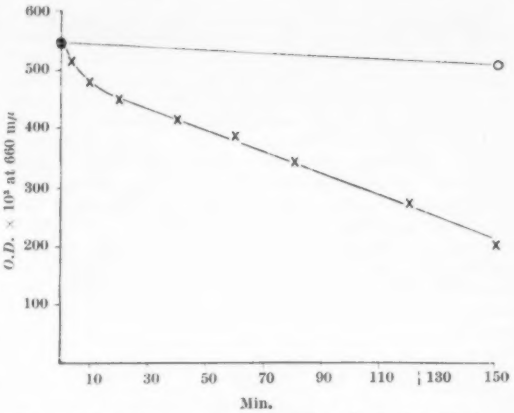

Fig. 1. Effect of lysozyme on the disruption of cells of *Azotobacter vinelandii* measured in 1-cm. cells at 660 mμ in a spectrophotometer. Assay system given in text. ○—○, No lysozyme; ×—×, lysozyme added

Azotobacter vinelandii (*O* strain) was kindly supplied by Dr. R. Burris and Dr. P. Wilson, Wisconsin University, Madison. The bacteria grown in 500 ml. of Burk's nitrogen-free medium[3] (*p*H 7·2) in litre flasks were well aerated in shake culture with sterile air. After 24-hr. growth, when the optical density readings of 3 ml. aliquots of the medium in 1 cm. cells were between 0·5 and 0·8, the cells were disrupted either with lysozyme or, alternatively, with an ultrasonic probe. The lysozyme treatment was a modification of Repaske's method[4] for lysing Gram-negative bacteria—50 ml. culture solution containing the cells was put in a 100 ml. conical flask, the *p*H adjusted to 8·0 with 0·01 *N* sodium hydroxide and the following reagents added; 5 ml. 0·1 *M* sodium pyrophosphate (*p*H 8·0), 5 ml. disodium versenate (0·16 mgm./ml.) and 5 ml. egg-white lysozyme (0·2 mgm./ml.). The decrease in optical density of the suspension was followed at 660 mμ in a 1-cm. spectrophotometer cell. The results in Fig. 1 show that at *p*H 8·0 almost complete lysis of the cells was achieved within 2 hr. The *p*H of the lysate was then adjusted to 7·2 with 0·01 *N* hydrochloric acid since nitrogen fixation in whole cells is maximal at this value.

The ultrasonic treatment with the Mullard probe (20 kc./s.) was as follows: 30 ml. culture medium containing the cells was put into a double-wall glass vessel (40 ml. capacity) which was kept cool by circulating iced water through the jacket. The contents were agitated with a magnetic stirrer and the cells were subjected to ultrasonic treatment for 15 min.

Cell-free extracts from either treatment were prepared by centrifuging at 25,000*g* for 30 min. in a refrigerated centrifuge at 4° C. Microscopic examination confirmed the complete absence of whole cells from these extracts.

Whole cells or extracts of *Azotobacter* were exposed to nitrogen-15 in 25 ml. sterilized Erlenmeyer flasks fitted with Thunberg type stoppers so that the contents, usually 10 ml., could be evacuated to 0·1 mm. mercury before introducing the following gas

mixture : 30 per cent nitrogen : 30 per cent oxygen : 40 per cent helium. The nitrogen was 30 per cent enriched with nitrogen-15. The vessels were sealed and put on a reciprocator for 18 hr. (80 oscillations/min.) at 30° C. The samples were digested with 3-ml. sulphuric acid (analytical reagent) s.g. 1·84, 0·5 gm. catalyst mixture (4 gm. mercuric oxide : 50 gm. potassium sulphate) in micro-Kjeldahl flasks for 6 hr. A suitable aliquot containing between 30 and 400 μgm. total nitrogen, as determined in the Markham apparatus, was distilled into 5 ml. 0·07 *N* sulphuric acid (analytical reagent) and the volume reduced to approximately 1 ml. in a boiling-tube before transferring it into one arm of a Rittenberg tube. The enrichment of nitrogen-15 in the samples was determined by the method of Sims and Cocking[5].

Table 1. Fixation of Nitrogen-15 in Extracts of *Azotobacter vinelandii*

Atom percentage nitrogen-15 excess

A. Extracts prepared by lysozyme treatment

	(1) Whole cells	(2) Lysis of cells with lysozyme. Supernatant solution used after centrifuging at 25,000*g* for 30 min.	(3) Boiled supernatant solution from (2)	(4) Supernatant solution from (2) treated with 10 per cent w/v trichloracetic acid
Exp. 1	4·00	0·22	0	0
Exp. 2	3·54	0·54	0	0

B. Extracts prepared by ultrasonic treatment

(1) Whole cells	(2) Ultrasonic treatment of cells (15 min.)	(3) Supernatant solution after centrifuging at 25,000*g* for 30 min.	(4) Boiled supernatant solution from (2)
2·73	2·54	0·385	0

The results in Table 1 show that the cell-free extracts of *Azotobacter* prepared by either method incorporate appreciable amounts of the stable isotope. The ultrasonic treatment of the cells did not appear to affect the nitrogen-fixing mechanism since enrichment of the isotope in the homogenate was similar to that of whole cells. Even after high-speed centrifugation the incorporation of the tracer into the cell-free extracts, although reduced, was quite substantial. Work is now in progress to determine the mechanism of nitrogen fixation in the cell-free preparations and, in particular, the nature of the contributory factors in the culture medium in which the organism was grown.

The mass spectrometer measurements were made for us at the Physical Chemistry Department of this University through the courtesy of Dr. W. J. Dunning and later by Dr. D. H. Tomlin, Physics Department, University of Reading. We acknowledge with thanks the help received from the two Departments.

D. J. D. Nicholas*
D. J. Fisher

Long Ashton Research Station,
University of Bristol.
Jan. 8.

* Member of the Scientific Staff of the Agricultural Research Council seconded to the Long Ashton Research Station.

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Simplified Bulk Growth of *Vibrio fœtus*

The cultivation of *Vibrio fœtus* in quantity, for antigen production, is generally regarded as rather difficult and costly. Commonly employed culture media are semi-solid 'Thiol' (Difco) and *Brucella* broth ('Albimi'), both containing 0·1 per cent agar.

A recent paper[1] summarizes much of present knowledge on the subject, and describes the adaptation of a previously published method[2] for *Pasteurella multocida*, using a special liquid medium. Apart from a French reference[3] we have found no mention in the literature of the employment of ordinary (nutrient) agar for the growth of *V. fœtus*, and no mention at all of the use of broth.

The nature of vaginal 'exudates' and other specimens from which we recovered *V. fœtus* led us to suspect that this organism thrived best in the presence of abundant moisture. We found that it grew more readily and luxuriantly on solid media, for example, when the condensation water had not been removed by drying (for example, during prior incubation as a sterility check, which we omit). Serial subculturing on blood-agar plates was usually then successful.

We originally used nutrient agar (equal parts meat extract[4] and Martin's peptone[5] plus 1·5 per cent agar) treated in this way for the production of antigen, setting it in 8 oz. 'medicine' bottles lying flat and distributing over the surface about 20 × 0·08 ml. heaps of young *V. fœtus* culture in semi-solid agar (equal parts meat extract and Martin's peptone + 0·1 per cent agar). After incubation in less than 10 per cent carbon dioxide the growth was harvested by washing with formol–saline, physiological saline or broth. The last two have the advantage that a second crop can be harvested after simply re-incubating the original agar bottles without further sowing.

In semi-solid agar, in which the inoculum remained near the surface, rich growth occurred in tubes down to about 1 cm. below the surface under 10 per cent carbon dioxide and in zones at various depths in air. Increased depth of the growth disks below the surface is associated with reduction in catalase activity, which usually reappears on subculture under 10 per cent carbon dioxide.

For bulk culture, the semi-solid agar was placed in wide, flat-bottomed glass vessels to form a shallow layer the depth of which approximated that to which *V. fœtus* grew in tubes of such agar when incubated under 10 per cent carbon dioxide, namely, 1–2 cm. After incubation at 37° C. for 2–4 days, harvesting was carried out by adding 10 volumes of saline for each volume of medium present.

The agar was separated by centrifugation for 15 min. at 500*g* and the bacteria sedimented by a second centrifugation for 15 min. at 3,000*g* in an angle head. Failure to remove the agar results in difficulties in reading the vaginal mucus agglutination test.

The cells were washed by resuspending and centrifuging three times with formol–saline (physiological saline containing 0·3 per cent formalin), *p*H 7, and then resuspended, in formol–saline containing 0·5 per cent phenol, to the opacity desired for the vaginal mucus agglutination test.

It was then found that *V. fœtus* could be grown in nutrient broth (equal parts meat extract and Martin's peptone) without the addition of agar. In vertical tubes the inoculum sank to the bottom and no growth occurred ; but when the broth was dispensed in a shallow layer (1–2 cm.) in wide, flat-bottomed vessels,

as just described for semi-solid agar, good growth resulted. Greater depth of medium could probably be used if mechanical agitation were employed. Harvesting and washing procedures were as for other bacteria grown in broth.

After two days incubation in an atmosphere of 10 per cent carbon dioxide we were usually able to prepare a volume of antigen suspension (of opacity 2 on the Burroughs Wellcome scale) a little greater than that of the broth originally inoculated. Incubation for four days generally yields about double the volume, and even five days incubation does not seem to impair the specificity of the antigen.

To date six strains of *V. fœtus* (the English 'Longsdon' and '1980', and four local field strains isolated at Glenfield) have been found to grow well in both media. Each of the four local strains did so immediately after primary isolation on blood agar plates. At present semi-solid agar is used for stock cultures and broth for antigen production.

We are grateful to Mr. J. C. Keast, director of veterinary research, New South Wales Department of Agriculture, for his encouragement and interest in this work, and to Dr. B. P. Setchell, also of this Station, for helpful advice in the preparation of notes for publication.

Dusan Jakovljevic
H. E. R. Beattie

Veterinary Research Station,
Glenfield,
New South Wales.

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GENETICS

Inheritance of Asymmetry in a Water-boatman (*Krizousacorixa femorata*)

Asymmetry of the abdominal segments in the corixid males is a regular occurrence with the sense of asymmetry, dextral or sinistral, regularly uniform intraspecifically. One finds among the males no intermediate forms, for all the asymmetrical structures of a dextral male are perfect mirror-images of those in a sinistral male and vice versa. More particularly, the sex-limited structures are confined to the body wall, and more precisely, to the last six segments where the exoskeleton and musculature display an asymmetrical pattern, emphasized by an oval black body (the strigil) and a curved genital capsule. In the dextral male the strigil is limited to the right margin of the sixth segment and the genital capsule is directed to the right. These asymmetrical structures are, of course, mirror-images of those in a sinistral male, while in the females bilateral symmetry prevails. Instances of *situs inversus*[1] are rare.

At Lake Zumpango, near Mexico City, I discovered an unusually high frequency of *situs inversus* in a large population of *K. femorata*, or water-boatman. In a sample of 650 males, 475 were dextral and 175 sinistral. Though previous investigators have reported the phenomenon of *situs inversus* in this corixid, I have not found any published account of the inheritance of dextro-sinistral asymmetry in this or any other species of corixid.

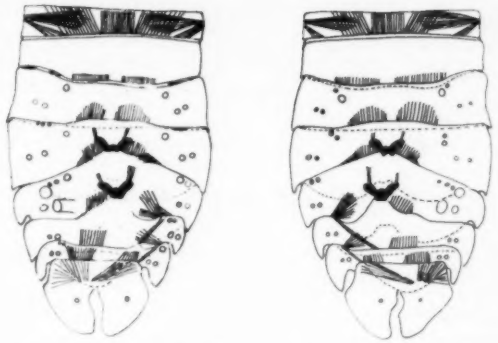

Fig. 1. Ventral view of the abdominal exoskeleton and musculature in asymmetrical males, dextral and sinistral, of *K. femorata*, Guer.

In elucidating the mode of inheritance by means of breeding experiments, single-pair matings in various combinations were made in the laboratory. An all-dextral male line of some ten generations was established. Attempts to produce an all-sinistral line, however, resulted in families containing dextral and sinistral males in different proportions. The results from three single-pair matings of a sinistral male and a virgin female are shown in Table 1, suggesting a 2 : 1, 1 : 1, and 1 : 2 ratio.

Table 1. Progenies from Crosses between Sinistral Males and Virgin Females

Family 1	52 sinistral ♂♂	49 dextral ♂♂	62♀♀
Family 2	52 sinistral ♂♂	25 dextral ♂♂	90♀♀
Family 3	17 sinistral ♂♂	36 dextral ♂♂	50♀♀

A sequence of experimental matings of dextral and sinistral lines was carried out and the segregation ratios analysed; these will be published in full detail elsewhere. From the results, however, one can conclude *ex hypothesi* that the inheritance of the polymorphic characteristic of asymmetry depends upon an allelomorphic series of three genes, D, D^s, and d, of which D (dextrality) is dominant to D^s (sinistrality), which in turn is dominant to d (dextrality). The intermediate member of the series is lethal as a homozygote.

I am grateful to Sir Ronald Fisher for his direction of this work.

Walter Peters*

Department of Genetics,
University of Cambridge.

* Present address: Department of Biology, Loyola University, Chicago.

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Triploid Rat Embryos and Other Chromosomal Deviants after Colchicine Treatment and Polyspermy

Austin and Braden[1] have shown in their classic paper on polyspermy in the rat that dispermy leads to a triploid fertilized egg and that such an egg may cleave normally up to at least the eight-cell stage. These conclusions have been confirmed by the recent investigations of one of us[2]. However, Braden and Austin[3] found no instance of triploidy among rats born from delayed mated females in spite of the presence of about 9 per cent dispermic eggs at fertilization stages.

The fate of heteroploid mammalian embryos coming from sources other than polyspermy has mostly been

Table 1. Effects of Intraperitoneal Injections of Colchicine on Fertilization in the Rat

Interval mating-injection	Dose (mgm./100 gm. body-weight)	No. of females	Penetrated eggs	Polyspermic eggs	Eggs with suppressed second polar body	Androgenetic eggs	Eggs with subnuclei
2 hr.	0·025–0·05	13	111	7 (6·3%)	42 (38%)	1 (0·9%)	16 (14%)
2½ hr.	0·05	6	45	0	5 (11%)	17* (38%)	8 (18%)

* Includes four possible androgenetic eggs at the 2- to 3-cell stage.

Table 2. Chromosome Classes of 9–15 Days Old Rat Embryos after Different Treatments to induce Heteroploidy

Age of embryos (days)	Group	No. of pregnant females	No. of embryos	Classified as			
				Diploid	Triploid	Mosaic	Without mitoses
8–12	Colchicine	14	63	42	2	13	4
	'polyspermy'	12	130	115	8	6	1
13–15	Colchicine	5	22	14	0	1	7
	'polyspermy'	9	89	84	0	2	3

examined in the mouse[4]. Some spontaneous triploid and mosaic embryos were recovered in 'silver' females up to 9½-days gestation. But triploids were absent in the offspring of 'silver' mice (Beatty, R. A., personal communication). No heteroploid adult was observed either in the offspring of colchicine-treated mice[5]. It would seem, therefore, that most, if not all, heteroploid (triploid) mouse embryos die some time between mid-term and parturition.

In the present communication we report attempts to induce experimentally polyspermy and other types of heteroploidy in the rat. Parallel with this work, the fate of heteroploid rat embryos has been studied by chromosomal examination.

Adult female rats of the Wistar *CF*, Long-Evans, and Sherman strains were used, all mated with Wistar *CF* males towards the end of œstrus. It is known[6] that if mating is not allowed until after ovulation, sperm penetration in the rat begins about 2–4 hr. after copulation and then is completed, in any one rat, in 1–2 hr. The eggs were examined under the phase-contrast microscope in the living state and, in some cases, after acetocarmine staining under the coverslip.

In an attempt to induce polyspermy, eight females of each of the three strains used were subjected to a moderate hyperthermia for 3 hr. after mating. The body-temperatures were maintained at 40–41° C. by keeping the rats in a box heated at 35–36° C. The incidence of polyspermic (dispermic) eggs reached 8–10 per cent in the Sherman and Long-Evans strains but only 3·5 per cent in the Wistar *CF* strain.

In order to inhibit the second polar division, Wistar *CF* females were injected intraperitoneally with colchicine after mating. In earlier work[7], intraperitoneal injections of 0·05–0·1 mgm. colchicine per 100 gm. body-weight, 1–2 hr. after delayed matings, caused suppression of the second polar body in about 70 per cent of the eggs. Other abnormalities were: eggs with a single (presumably male) pronucleus and those with subnuclei in place of the female pronucleus. Our results are shown in Table 1.

It appears that the frequency of the different anomalies depends closely on the time of application. If the drug is applied at 2 hr. after mating, the second polar body is suppressed in many eggs; on the other hand, androgenesis is the principal anomaly at 2½ hr. In the latter case the second 'polar body' is formed

Fig. 1. Diploid metaphase ($2n = 42$; 12-days-old embryo) (× 2,500)

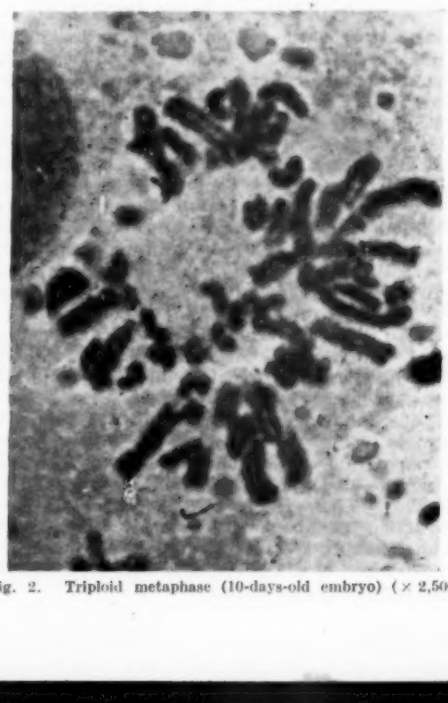

Fig. 2. Triploid metaphase (10-days-old embryo) (× 2,500)

without a spindle mitosis and includes the whole female chromatin. The higher doses of the drug frequently block the development of the pronuclei for up to 24 hr. Some evidence shows that androgenetic eggs may undergo cleavage, but their development stops at an early stage.

Twenty-four colchicine-treated females, and twenty-two females subjected to treatments to induce polyspermy (mostly of the Sherman strain), were killed 8–15 days after copulation. For the chromosomal examination whole embryos or, in later stages, the head were stained by acetic orcein after hypotonic pretreatment and squashed. Eighty-five embryos of the colchicine group and 219 embryos of the 'polyspermy' group were analysed; the results are given in Table 2.

Embryos classified as triploid contained predominantly triploid and near-triploid mitoses. Most of the mosaics contained triploid or near-triploid mitoses as well as other types of mitoses, the diploid number being, in general, the most frequent; these embryos might have come from originally triploid eggs. The remaining mosaics were diplo-aneuploid. There was practically no sign of 'somatic inconstancy' in the embryos classified as diploid. In an earlier study[6] by one of us, no deviation from the normal number was observed either in spermatogonia of adult rats.

Eight triploid embryos were highly retarded and clearly abortive; two triploids, however, both 10 days old and obtained in the 'polyspermy' group, were of normal size and appearance. Eight of the mosaic embryos were abortive while 14 appeared normal although more or less delayed in some cases.

To conclude, our results put forward new evidence that dispermic fertilization is a source of triploid embryos in the rat. It seems that most dispermic triploid embryos can become implanted and their further fate does not differ considerably from that of triploids of other origin.

Colchicine treatment after ovulation is an efficient method to induce heteroploidy in the rat; but few heteroploid embryos survive to mid-term. A large proportion of the heteroploid forms (including most triploids) die before or soon after implantation.

The disappearance of triploids, and the reduction in the number of mosaics, after 12 days gestation show that the chances of these heteroploid forms reaching term, whatever be their origin, are faint. This is in accordance with the failure (refs. 2–4 and Beatty, R. A., personal communication) to produce adult heteroploid (triploid) offspring. In fact, the 12 days old triploid embryos described here are, to our knowledge, the latest stage of triploidy recorded so far in any mammal.

L. Piko
O. Bomsel-Helmreich

Station de Physiologie Animale,
Jouy en Josas
(Seine-et-Oise).

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Fractionation of Genes

After study of a dwarf tribe of Papuans at Aiome in the mountains of New Guinea in 1958 (not yet published), the conclusion was reached that they originated as a single-gene dwarf mutation from their tall neighbours who live at lower altitudes. This conclusion has since been confirmed by Champness *et al.*[1], who find that the blood groups of the tall and dwarf tribes in this area are essentially the same while the serology of a dwarf tribe in another part of New Guinea was markedly different. This supports the view that in mankind dwarf tribes or races have originated many times independently in different parts of the world, as they are known to have done in animals. In Africa it was concluded[2] that the Congo Pygmies arose long ago as a single-gene achondroplastic dwarf mutation from a tall race probably with mahogany skin colour.

In an extensive study of dwarf tribes in Dutch New Guinea, Bijlmer[3] found records of male stature stretching, perhaps in a step-like series, from 167 cm. (occasionally more) in the talls to 144·9 cm. as the lowest mean stature for a particular dwarf tribe.

Contemplating these and various other facts of dwarfing during a journey in India during October–December 1959, the tentative conclusion was reached that the intermediate heights of some Papuan tribes must have been derived in part from back-crossing of dwarfs to talls, accompanied by fractionation of the original 'large' gene for dwarfing and the production of 'smaller' genes having various intermediate effects. This is in accordance with the view I have always held that some mutations occur with large effects, as well as many with small effects. Having reached the conclusion that fractionation of genes must occur in some dwarf races, it was boldly decided to discuss this principle as soon as opportunity permitted a description of the Aiome dwarf race.

That opportunity has not yet occurred; but in the meantime, through the kindness of Dr. L. T. Ride, vice-chancellor of the University of Hong Kong, I was able in January 1960 to read back-numbers of *Nature*. In the number for December 19, 1959, I found a paper[4] which in one sense forestalled, but in another sense confirmed, the point of view mentioned above.

Briefly stated, the conception of the sub-gene is based[5] on experiments with the *T*4 bacteriophage and later with certain bacteria and lower fungi. From study of small differences in the phenotypic expression of a pair of genes in the *cis–trans* or coupling and repulsion phases it is shown that the cistron is a unit within the gene, and it may contain more than a hundred sensitive points at which a mutant phenotype may occur.

In the work of Fahmy and Fahmy[4], a large number of sex-linked recessive visibles obtained at the *r* locus by irradiation of *Drosophila melanogaster* proved to be a pseudo-allelic series, apparently involving several functional sub-units (cistrons) one or more at a time. That these are all intra-genic point mutations is shown by the absence of any band deficiencies in the *X*-chromosomes. Complementation maps indicate that six cistrons are involved in this series, which can be arranged in a linear sequence with overlapping.

Since the cistron conception is now established for an insect it may be assumed to apply to genes generally, including those of man. If genes contain,

or consist of, cistrons then fractionation of the gene can occur, which will reduce the original genic effect. This principle is of wide importance in human genetics. In Eskimo *X* Nordic[6], the F_1 *X* Nordic can produce an individual having blue eyes, fair hair and white skin like the original grandfather. Thus the gene for blue eyes, for example, segregates as a complete unit in this racial cross. But in the European population many intergrades between blue and brown iris occur which have never been properly studied but which may be reasonably attributed to fractionation of the original gene.

As regards the blood groups, it is evident that *ABO* are original or ancestral genes, and that A_1, A_2, etc., are later developments produced by fractioning of the original gene so that its effect is milder in different degrees. Similarly, there is evidence that brachycephaly first appeared in the Upper Palæolithic as a marked departure from the previous dolichocephaly. Later, more extreme forms of brachycephaly as well as intermediate cephalic indices have probably been produced, partly by fractionation of the original gene, through hybridization or otherwise. Thus in many cases the more extreme form of a gene appears first and its lesser and later forms bridge the gap by means of a series of sub-genes.

R. Ruggles Gates

18 Concord Avenue,
Cambridge 38, Mass.

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GEOLOGY

Geological Reconnaissance of the Sör-Rondane Mountains (Queen Maud Land)

In the course of the summer field parties of the Expedition Antarctique Belge 1957–58, I carried out a geological reconnaissance in the Sör-Rondane ranges, unexplored up to then.

This massif extends over approximately 250 km. east and west (from 23° E. to 28° E.) and has a depth of about 100 km. The foot-hills of the chain lie about 150 km. inland from the coast, at approximately 72° S. latitude. The summits are elevated between 1,200 and 3,500 m. above sea-level and the snow-line lies between 1,000 and 3,000 m.

The present topographical features have resulted from glacial erosion followed by a long stage of post-glacial erosion due mainly to mechanical weathering. The highest peaks investigated show evidence of heavy glaciation.

The region investigated is formed entirely of crystalline rocks, there being no trace of non-metamorphosed sedimentary rocks, nor of epizonal metamorphism.

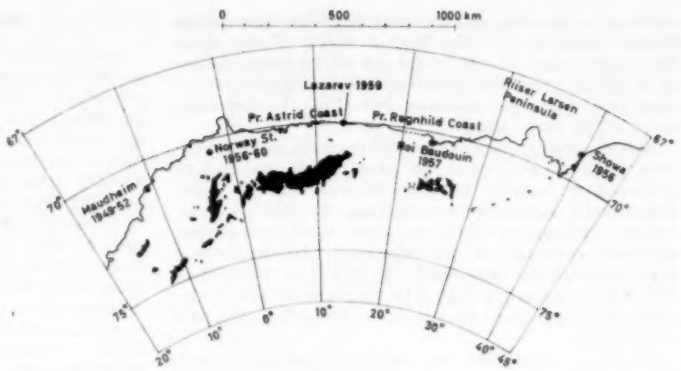

Fig. 1. Queen Maud Land

The nunataks to the north of the chain are formed of intrusive igneous rocks (coarse-grained red granite at Roemnesfjell, diorites at Nordtoppen and Småhausane).

The mountain chain itself is formed of migmatites and highly varied, though mainly biotitic and amphibolic, gneiss. In one occurrence (at Austkampane) the gneiss is interspersed with layers of pure crystalline limestone associated with banks of calcium silicate gneiss. Homogeneous massifs of dioritic gneiss are also found. The general direction of the gneiss is east–west; the dip is very variable.

The gneissic complex, at certain points, is transected by a disordered network of pegmatitic and granitic dykes. The intensity and widespread occurrence of this phenomenon are striking characteristics of the region.

The phenomena of anatexy and of migmatization are widespread. This gneissic complex obviously forms part of the eastern Antarctic Pre-cambrian complex. The igneous intrusives to the north of the chain are clearly later than the gneiss but of unknown age.

There is no evidence of mineralization either in the gneiss or in the igneous intrusives.

The following successive stages in the geological history of this region are identifiable: (1) the deposition of a vast and varied sedimentary complex, including limestone deposits, under geosynclinal conditions; (2) the folding and metamorphism of the sedimentary complex in a deep zone (upper catazone), accompanied by dioritic intrusions; (3) the intrusion of granitic and dioritic rocks into the gneiss; (4) the formation of granitic and pegmatic dykes cutting through the intrusive bodies.

The radioactivity dating of the samples at present being carried out will furnish more precise information as to the chronology of these stages.

I wish to thank Dr. Jacques Giot, who led the sled journey into the Sör-Rondane, and Drs. Paul and Jean Michot, who are carrying out the petrographical study of the samples collected.

The geographical names refer to the map of the Sör-Rondane Mountains, published by the Norsk Polarinstitutt, in 1957.

E. E. Picciotto

Laboratoire de Physique Nucléaire,
Université Libre de Bruxelles.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, May 30

UNIVERSITY OF LONDON (in the Anatomy Lecture Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. B. Segre (University of Rome): "Galois Spaces".*

UNIVERSITY OF LONDON (in the Chemistry Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. Sir Aubrey Lewis: "Agents of Cultural Advance" (Hobhouse Memorial Lecture).*

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Sir Mortimer Wheeler: "An Ancient Metropolis of the North-West Frontier; Recent Work at Charsada" (The Dickson Asia Lecture 1960).

Tuesday, May 31

UNIVERSITY OF LONDON (at the Institute of Archæology, Inner Circle, Regent's Park, London, N.W.1), at 5.45 p.m.—Mr. W. E. Griffiths: "Recent Excavations at Stone Circles in North Wales".* (Seventh of nine lectures on "Recent Archæological Discovery in Britain". Further lectures on June 7 and 14.)

Wednesday, June 1

GEOLOGICAL SOCIETY OF LONDON (at Burlington House Piccadilly, London, W.1), at 5 p.m.—Prof. E. Sherbon Hills (University of Melbourne): "Morphotectonics and the Geomorphological Sciences, with special reference to Australia" (Fifteenth William Smith Lecture).

UNIVERSITY OF LONDON (at Queen Mary College, Mile End Road, London, E.1), at 5.30 p.m.—Prof. S. Chapman, F.R.S. (Geophysical Institute, Alaska): "Electric Currents in the Earth's Ionosphere".*

INSTITUTE OF INFORMATION SCIENTISTS (at the College of Preceptors, 2 Bloomsbury Square, London, W.C.1), at 6.15 p.m.—Annual General Meeting. 7.30 p.m.—Prof. J. D. Bernal, F.R.S.: "Can Communications Science be used in Channelling Scientific Information?"

SOCIETY OF CHEMICAL INDUSTRY, HEAVY ORGANIC CHEMICALS GROUP (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. R. Holroyd: "Cross Fertilization of Petroleum and Chemical Industry Techniques through Heavy Organic Chemicals".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. G. C. Drew: "Alcohol and Skilled Performance".

Thursday, June 2

BRITISH ASSOCIATION FOR COMMERCIAL AND INDUSTRIAL EDUCATION (at the Polytechnic, Regent Street, London, W.1), from 10 a.m. to 4.15 p.m.—Conference and Exhibition on "Visual Aids for Technical Education".

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Dr. H. Godwin, F.R.S.: "Radiocarbon Dating and Quaternary History in Britain" (The Croonian Lecture).

MINERALOGICAL SOCIETY (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5 p.m.—Dr. S. J. Bach: "The Metabolic Fate of Protein-Nitrogen in the Mammal".*

UNIVERSITY OF LONDON (at Guy's Hospital Medical School, St. Thomas's Street, London, S.E.1), at 5.30 p.m.—Prof. C. Liébecq (Liège): "Biochemical Aspects of Glucose Utilization in Muscle Tissue".*

UNIVERSITY OF LONDON (at Queen Mary College, Mile End Road, London, E.1), at 5.30 p.m.—Prof. S. Chapman, F.R.S. (Geophysical Institute, Alaska): "Electric Currents Beyond the Ionosphere".*

WORSHIPFUL SOCIETY OF APOTHECARIES OF LONDON, FACULTY OF THE HISTORY OF MEDICINE AND PHARMACY (at Apothecaries Hall, Black Friars Lane, London, E.C.4), at 5.30 p.m.—Mr. K. D. Keele: "William Harvey: Pioneer of Medical Science" (First Annual Students' Lecture).

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Prof. M. Heidelberger: "Chemical Constitution and Immunological Specificity" (Centenary Lecture).

Friday, June 3

INSTITUTION OF CHEMICAL ENGINEERS (at the Imperial College of Science and Technology, Department of Chemical Engineering, Prince Consort Road, London, S.W.7), at 3.30 p.m.—Mr. N. G. Maroudas: "Mass Transfer in Liquid–Liquid Systems: Simultaneous Transfer of Two Solutes between Two Immiscible Solvents".

UNIVERSITY OF LONDON (at Queen Mary College, Mile End Road, London, E.1), at 5.30 p.m.—Prof. S. Chapman, F.R.S. (Geophysical Institute, Alaska): "The Solar Corona and the Earth's Outermost Atmosphere".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

MAY AND BAKER RESEARCH FELLOW (honours graduate in chemistry)—The Registrar, Wye College (University of London), Wye, Kent (June 1).

ASSISTANT LECTURER, Grade "B", IN BIOLOGY; and an ASSISTANT LECTURER, Grade "B", IN CHEMISTRY—The Principal, Peel Park Technical College, Salford 5 (June 2).

ASSISTANT LECTURER IN GENETICS; and a LECTURER OR ASSISTANT LECTURER IN PURE MATHEMATICS—The Registrar, The University, Leicester (June 4).

LECTURER (graduate in pharmacology, physiology, biochemistry or veterinary medicine) IN THE DEPARTMENT OF VETERINARY PHARMACOLOGY—The Secretary, The University, Edinburgh (June 4).

ASSISTANTS (2) IN MATHEMATICS—The Secretary of University Court, The University, Glasgow (June 6).

UNIVERSITY DEMONSTRATOR (with an honours degree in chemistry or agricultural chemistry) IN SOIL SCIENCE—The Secretary, School of Agriculture, The University, Cambridge (June 8).

LECTURER or ASSISTANT LECTURER (qualified in pure or applied mathematics) IN MATHEMATICS—The Registrar, University College of North Staffordshire, Keele, Staffs (June 9).

DEMONSTRATOR IN THE DEPARTMENT OF PHYSICS—The Registrar, University College of North Staffordshire, Keele, Staffs (June 10).

LECTURER IN STATISTICS IN THE DEPARTMENT OF PURE MATHEMATICS; a LECTURER IN THE DEPARTMENT OF MATHEMATICAL PHYSICS; LECTURERS (2) IN THE DEPARTMENT OF PHYSICS; LECTURERS (2) IN THE DEPARTMENT OF CHEMISTRY; a LECTURER (preferably MYCOLOGIST) IN THE DEPARTMENT OF BOTANY; a LECTURER IN THE DEPARTMENT OF MECHANICAL ENGINEERING; a LECTURER IN THE DEPARTMENT OF ENGINEERING PRODUCTION; LECTURERS (3) IN THE DEPARTMENT OF CIVIL ENGINEERING; LECTURERS (2) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING; a LECTURER IN THE DEPARTMENT OF CHEMICAL ENGINEERING; a LECTURER IN THE DEPARTMENT OF PHYSICAL METALLURGY; and a LECTURER IN THE DEPARTMENT OF INDUSTRIAL METALLURGY—The Deputy Registrar, The University, Edgbaston, Birmingham 15 (June 11).

TUTORIAL ASSISTANTS (2) IN THE DEPARTMENT OF GEOLOGY—The Registrar, University College of Wales, Aberystwyth (June 11).

ASSISTANT EXPERIMENTAL OFFICER (with a pass degree or five subjects at G.C.E. "O" level and at least two at "A" level) IN THE DEPARTMENT OF POTATO GENETICS, to assist in routine tests and pathological investigations—The Secretary, John Innes Horticultural Institution, Bayfordbury, Hertford, Herts (June 15).

LECTURER (with a degree in textile industries, followed by research experience; or chemistry, followed by specialization in textile chemistry) IN TEXTILE CHEMISTRY at the Home Science School, University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1, or The Registrar, University of Otago (New Zealand and London, June 15).

ASSISTANT LECTURER IN CHEMISTRY—The Registrar, The University, Leicester (June 18).

LECTURER or an ASSISTANT LECTURER (veterinary surgeon, or possessing a degree in an appropriate biological subject) IN VETERINARY PATHOLOGY—The Secretary, Royal Veterinary College (University of London), Royal College Street, London, N.W.1 (June 18).

LECTURER or SENIOR LECTURER IN APPLIED MATHEMATICS—The Registrar, The University, Sheffield (June 18).

SENIOR LECTURER IN SOLID STATE PHYSICS—The Registrar, The University, Sheffield (June 18).

LECTURER or ASSISTANT LECTURER IN APPLIED MATHEMATICS—The Registrar, The University, Leeds 2 (June 24).

CHAIR OF MECHANICAL ENGINEERING AND HEAD OF THE DEPARTMENT—The Registrar, The University, Nottingham (June 30).

LECTURER (with a thorough knowledge of the physics of materials, and industrial or research experience involving semiconductors, polymers, magnetic materials, etc.) IN MATERIALS TECHNOLOGY IN THE DEPARTMENT OF ELECTRONIC ENGINEERING—The Registrar, University College of North Wales, Bangor, North Wales (June 30).

LECTURERS (2) IN PSYCHOLOGY at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 30).

LECTURERS or ASSISTANT LECTURERS (with at least a good honours degree in mathematics and experience in teaching and research) IN MATHEMATICS at the University of Malaya, Kuala Lumpur—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Malaya and London, June 30).

POSTDOCTORAL RESEARCH FELLOWS (with previous experience either in the chemical investigations of the structure of proteins or in the synthesis of peptides)—Dr. G. T. Young, The Dyson Perrins Laboratory, The University, South Parks Road, Oxford (June 30).

WAYNFLETE PROFESSOR OF PURE MATHEMATICS—The Registrar, University Registry, Oxford (June 30).

ASSISTANT DIRECTOR OF THE SOLAR PHYSICS OBSERVATORY, for research in solar or stellar physics, with some lecturing and light administration—The Director, Observatories, The University, Madingley Road, Cambridge (July 1).

SENIOR LECTURER and a LECTURER IN PHYSICS at Victoria University of Wellington, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, July 1).

CHAIR OF PHARMACOLOGY in the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong and London, July 15).

PROFESSOR, and a READER IN THE DEPARTMENT OF MATHEMATICS, University of Rajshahi, East Pakistan—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (August 31).

ASSISTANT EXPERIMENTAL OFFICER (CHEMISTRY) (male or female, with a university pass degree in chemistry or agricultural chemistry)—The Secretary, Welsh Plant Breeding Station, Plas Gogerddan, near Aberystwyth.

ASSISTANT, Grade "B" (with a good honours degree, and preferably industrial or research experience), FOR MATHEMATICS—The Clerk to the Governors, South-East Essex Technical College, Longbridge Road, Dagenham, Essex.

ASSISTANT PROFESSOR (medically qualified or with a science degree of appropriate quality) IN THE DEPARTMENT OF MEDICAL BACTERIOLOGY—The Dean, Faculty of Medicine, The University of Alberta, Edmonton, Alberta, Canada.

CHEMISTRY MASTER, to teach throughout the school to "A" and "S" level G.C.E.—The Headmaster, The Perse School, Cambridge.

COMPUTER to work in a small team concerned with plasma research —Prof. D. Gabor, F.R.S., Electrical Engineering Department, Imperial College of Science and Technology, London, S.W.7.

EXPERIMENTALIST (with G.C.E. at "A" level, H.N.C. or equivalent and appropriate experience), to work in the Proton Physics Group of the Nuclear Physics Division engaged in the investigation of various methods, such as plating and vacuum evaporation, for producing thin targets for exposure in the Proton Linear Accelerator and also to work on nuclear detectors and to participate in the experimental work of the group which is using the P.L.A. for studying nuclear structure—The Senior Recruitment Officer (1672/34), U.K.A.E.A., A.E.R.E., Harwell, Didcot, Berks.

JUNIOR LECTURER (Ph.D. standard in chemistry or biochemistry, and interested in pursuing research in microbiological chemistry) IN THE DEPARTMENT OF BIOCHEMISTRY—The Dean, London School of Hygiene and Tropical Medicine (University of London), Keppel Street, London, W.C.1.

LECTURER (graduate, with teaching and/or industrial experience in electronic and control technology, or a related branch of applied physics) IN THE SCHOOL OF PHYSICS AND APPLIED SCIENCE—The Registrar, College of Technology and Commerce, Leicester.

LECTURER (honours graduate, or with an equivalent qualification, preferably with industrial and/or teaching experience in statistics) IN STATISTICS AND MATHEMATICS—The Principal, Medway College of Technology, Horsted, Maidstone Road, Chatham, Kent.

LECTURERS, Grade "B" (2) (graduates of a British university, one with qualifications and experience in electronics, and the other with qualifications and experience in theoretical and nuclear physics) —Clerk to the Governing Body, Battersea College of Technology, London, S.W.11.

PROFESSOR (with a background of university teaching and significant research accomplishment, with relevant professional experience) OF MECHANICAL ENGINEERING (Chairman of the Department)—The Dean of Engineering, University of Waterloo, Waterloo, Ontario, Canada.

RESEARCH ASSISTANT (with a degree in botany, and preferably an interest in mycology) IN BOTANY—The Director of Education, The Polytechnic, 309 Regent Street, London, W.1.

RESEARCH ASSISTANT (with a degree in science or graduate member of the Royal Institute of Chemistry, or graduating this summer and qualified to work for a higher degree or research diploma) IN ORGANIC CHEMISTRY—The Principal, Bolton Technical College, Bolton, Lancs.

RESEARCH ASSISTANTS (honours graduates in physics or students in the present graduation class), for work on problems concerned with counting techniques and high energy physics, gas discharges, spectroscopy or electronics—The Clerk to the Governors, Northern Polytechnic, Holloway Road, London, N.7.

RESEARCH BIOCHEMIST (Ph.D., preferably with a knowledge or research experience in the fields of pharmacology or pharmacological chemistry, clinical biochemistry or spectrophotometry), for investigations into the biochemical actions of drugs currently used in the treatment of mental illness, proceeding in conjunction with clinical studies on therapeutic action—The Director of Clinical Research, Crichton Royal, Dumfries.

RESEARCH OFFICER, BIOCHEMIST (with a good honours degree in chemistry or biochemistry, with postgraduate experience in biochemistry, preferably of animal nutrition and/or animal physiology) IN THE ANIMAL HUSBANDRY DIVISION, East African Agriculture and Forestry Research Organization, Kenya—Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.195/151/C.1.

SENIOR LECTURER (with a good honours degree in mathematics) IN PURE MATHEMATICS—The Clerk to the Governors, Woolwich Polytechnic, London, S.E.18.

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